Dental Implants: Patient Selection Factors

Evidence-Based Review

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Important Notes:

- This evidence based review summarises information on dental implants published since 2004. It is not intended to replace clinical judgement, or be used as a clinical protocol.
- If a particular factor (e.g. bruxism or any other parafunctional habit) is not discussed in this report, it is because no publihed literature regarding that factor was located. In these circumstances, the conclusions of the previous report[1] still apply.
- A reasonable attempt has been made to find and review papers relevant to the focus of this EBH review. It does not claim to be exhaustive.
- The content of this document does not necessarily represent the official view of ACC or represent ACC policy.

Summary

An evidence-based review of patient selection factors that affect dental implant survival and/or success has been conducted to supply evidence to update the existing ACC Dental Implant Guidelines (2006)[2]. Fifty-five papers were reviewed. The overall quality of the published research was relatively poor and so, the guideline development will involve considering the existing evidence, expert opinion and a consensus process.

The main findings of the review are:

- Smoking less than ten cigarettes per day, as a single risk factor, may not increase the risk of failure sufficiently to deny treatment but dental implants may be contra-indicted in smokers who have other relevant risk factors.

- There is insufficient evidence that people with a history of treated periodontitis have a significantly elevated risk of implant failure but the consensus view is that people with periodontitis should be treated for this condition before being considered for implant therapy.

- There is a consensus of opinion that people with poor oral hygiene, infection or uncontrolled caries should not be offered dental implants.

- There is weak evidence that dental implants placed in the maxilla may have a greater risk of failure.
- There is conflicting evidence that bone quality or quantity have a significnat effect on the risk of implant failure.
- There is some weak evidence that implants placed after maxillary sinus augmentation may have an increased risk of failure but there is no evidence that other bone graft/augmentation techniques alter significantly the risk of implant failure.
- Older age, as a single risk factor, is not a contraindication for implant placement.
- There is a consensus of opinion that implant placement should be delayed in young people until growth is complete.
- There is some evidence that implant failure rates in the maxilla are usually significantly increased in people who have previously had irradiation of the jaw, regardless of the total radiation dose.
- There is a consensus opinion that dental implants should not be placed in people undergoing active chemotherapy.
- Medical advice should be sought for people with coagulation disorders or taking anticoagulant medication before proceeding with implant placement.
- Bisphosphonate medication is a contraindication to implant placement due to the risk of osteonecrosis of the jaw.
- There is insufficient evidence that well controlled diabetes type II is a significant risl factor for implant failure
- There is no evidence whether diabetes type I, asthma, rheumatoid arthritis is or is not a significant risk factor for implant failure
- There is insufficient evidence that the following factors are significant risk factors for implant failure:
    - type of edentulousness or proximity to natural dentition
    - placement in the posterior region of a jaw
    - osteoporosis
    - type of prosthesis
    - a history of chemotherapy treatment
    - cardiovascular disease, including hypertension and hypercholesterolaemia
    - thyroid disease, gastric problems or Crohn's disease
    - hormone replacement therapy, menopausal status or history of a radical hysterectomy
    - steroid, antidepressant, antihypertensive, statin, antimicrobial or non-steroidal anti-inflammatory medications.

Dental Implants

Introduction

Missing teeth have traditionally been replaced with dentures or bridges permitting restoration of chewing function, speech, and aesthetics. Dental implants offer an alternative.

These implants are inserted into the jawbones to support a dental prosthesis and are retained because of the intimacy of bone growth on to their surface. This direct structural and functional connection between living bone and implant surface, termed osseointegration, was first described by Brånemark 1977.[3]

Studies have reported a high level of predictability and success using this treatment modality for a variety of clinical situations in both people who are edentulous and partially dentate.[4]

ACC pays for around 80% of all dental implants in New Zealand and the total costs are increasing. In 1999 the surgical costs were approximately $1m and increased to $5.1m in the July 2008-June 2009 period. [personal communication with Rosemary Kennedy, Dental Advisor, Health Purchasing Provider Relationships, ACC]

In 2004 guidelines were developed by ACC to supply guidance on patient selection factors, patient satisfaction and cost factors. A request was made in 2007 to update the evidence review for these guidelines so as to keep entitlements in line with necessary and appropriate treatment.

Objectives

The objective is to update the evidence base of the ACC Dental Implant Guidelines focussing on the patient selection factors.

Criteria for selecting studies for this review

Types of studies:

Randomised controlled studies, systematic reviews, clinical practice guidelines, and cohort, case-control or case series studies that reported on patient selection factors.

Types of participants:

People of any age who had dental implants placed for whatever reason.

Types of exposures:

Risk factors for implant failure i.e. smoking, diabetes, parafunction including bruxism, bone grafting, bone quality/volume, osteoporosis, menopause and hormone replacement therapy, hypothyroidism, cardiovascular disease, irradiation of jaw, oral health (infection, periodontitis, poor oral hygiene, uncontrolled caries), general health status, site of implant placement (mandible vs. maxilla & posterior vs. anterior location), degree of edentulousness, force on implant, age and medication.

Types of outcome measures:

Risk of implant survival, success or failure expressed as relative risk, odds ratio or statistical significance (p-value), and pooled survival estimates.

Search strategy

The following databases were searched: Medline, EMBASE, Premedline, CINAHL, All EBM reviews, and PsychInfo. The search strategies were run in January 2008 and repeated in November 2008.

Search strategies are shown in Appendix A

Inclusion criteria:

- only papers published in English that were readily available
- papers published from 2004 onwards or before 2004 if not in previous review.

Exclusion criteria:

Papers that dealt exclusively with:

- gene polymorphism
- implant overdentures/fixed complete prosthesis
- timing of loading of implant
- placement protocols (1 vs. 2-stage)
- type/surface of implant
- orthodontic anchorage.

Methodological quality

Reviewed papers were assigned a level of evidence according to the SIGN[5] revised grading system (Table 1).

Table 1: Scottish Intercollegiate Guidelines Network (SIGN) Revised Grading System

LEVELS OF EVIDENCE	
1++	High quality meta analyses, systematic reviews of RCTs, or RCTs with a very low risk of bias
1+	Well conducted meta analyses, systematic reviews of RCTs, or RCTs with a low risk of bias
1 -	Meta analyses, systematic reviews of RCTs, or RCTs with a high risk of bias
2++	High quality systematic reviews of case-control or cohort or studies High quality case-control or cohort studies with a very low risk of confounding, bias, or chance and a high probability that the relationship is causal

2+	Well conducted case control or cohort studies with a low risk of confounding, bias, or chance and a moderate probability that the relationship is causal
2 -	Case control or cohort studies with a high risk of confounding, bias, or chance and a significant risk that the relationship is not causal
3	Non-analytic studies, e.g. case reports, case series
4	Expert opinion

Results and discussion

A total of 200 papers were reviewed out of over 600 references and 55 were considered to be relevant to this review. The majority of the studies were of a retrospective cohort design.

Overall the quality was relatively poor i.e. high risk of bias, confounding or chance and a significant risk that the relationship is not causal. This was mainly due to the inherent limitations of retrospective study design, poor reporting of baseline characteristics, lack of reporting loss to follow-up, measurement limitations and lack of consideration and/or adjustment for potential confounding factors.

In addition, the studies were often underpowered, especially those that showed inconclusive results and there was considerable heterogeneity of implant types, surface characteristics, definitions and measurement of exposures & outcomes, and surgical protocols.

With respect to external validity, most studies were conducted in University settings and did not (as far as can be ascertained) involve people who had tooth loss due to injury. These factors need to be considered when assessing the applicability and generalisability of the evidence to the relevant ACC population and to private dental practice settings.

Dental implant placement can be a highly successful intervention with overall cumulative survival rates being, typically, greater than 90% up to 20 years.[6-13]

In a meta-analysis[14]of prospective longitudinal studies of at least five years duration found that about 2.5% of all implants placed are lost prior to functional loading and another 2-3% are lost after the prosthesis is attached to the implant.

Patient selection factors

Effect of smoking

Thirty-seven papers were reviewed that evaluated the effect of smoking on implant survival/success, including 3 systematic reviews, 18 cohort studies, 6 case series, 9 narrative reviews and one consensus guideline (Table 2).

Of the 3 systematic reviews, all found that smoking significantly increased the risk of implant failure:

- Two of the reviews[15, 16] estimated the pooled odds ratio (OR) to be 2.17 & 2.38 respectively
- The other[12] estimated the pooled difference in survival rates between smokers and non-smokers to be 2.98%

- The systematic review[15] also found that there was a significant increase in the risk of failure of implants placed in the maxilla of smokers compared to non-smokers: OR [maxilla] = 2.06 (95%CI: 1.61-2.65) but no significant increase in the risk of failure of implants placed in the mandible of smokers compared to non-smokers: OR [mandible] = 1.32 (95%CI: 0.72-2.4), suggesting that smoking has more influence on implants placed in the maxilla.

All of the four cohort studies considered to have a low risk of confounding, bias or chance found that smoking had a detrimental effect on implant survival:

- People who smoked between 10 & 20 cigarettes per day had a statistically significant greater risk of early implant failure compared to people who don't smoke (OR=1.90) and that those who smoked >20 cigarettes per day had an even greater risk (OR=2.18)[6]

- Smokers had an significantly increased risk of overall complications (HR=2.31 (95%CI: 1.29-4.16); p=0.0051) and 'inflammatory' complications (including mobility, pain, infection, & peri-implantitis) (HR=3.26 (1.74-6.10) p=0.0002)[17]

- Smokers had an increased risk of implant failure (defined simply as "removal") (HR=3.5 (95%CI: 1.7-7.2) p<0.001) on multivariate analysis[17]

- An increased risk of implant loss (HR=2.6 (95%CI: 1.8-3.9)) was found on multivariate analysis[18].

Eight of the 14 cohort studies considered to have a high risk of confounding, bias or chance also found that smoking had a detrimental effect on implant survival:

- Smoking increased the risk of early failure from 1.12% to 5.56% (p<0.001)[8]

- Smoking at the time of implant placement surgery increased the risk of early implant failure (RR=1.69; p=0.05) and that a positive smoking history was associated with late (after the prosthesis was placed) implant failure (RR=1.91; p=0.05)[19]

- A study[11] that looked at the effect of osteoporosis on implant survival in women found that smoking increased the risk of implant failure (HR=2.6 (95%CI: 1.20-5.63) p=0.016)

- Moheng[20] found that smoking increased the risk of implant failure (RR=14.4; p<0.0001) in a small prospective study of a highly selective population

- A larger study[21] found that the risk of failure was increased by 1.39 times in smokers (p=0.03)

- A study[13] assessing the long-term survival and risk factors for implant failure of screw-type implants in a private practice found that smoking increased the risk of implant failure by 1.04 times

- Smoking more than 20 cigarettes per day increased the risk of implant failure (OR = 2.50) compared to smoking less than 20 per day in a retrospective cohort study[22]

- A study[23] investigating the survival rates of dental implants in people who had had a successful dentoalveolar reconstructive procedure found that the risk of failure in smokers was increased by 4.4 times.

Six of the 14 cohort studies considered to have a high risk of confounding, bias or chance found that smoking did not adversely affect the risk of failure:

- Smoking[7] did not significantly alter the risk of late implant failure i.e. up to abutment connection
- A lower survival rate was found in smokers ($p<0.013$) in another study[9] but this was not significant when adjusted for potential confounders
- There was no significant difference in implant failure rate between those who had never smoked compared to a group consisting of current & ex-smokers ($p=0.16$)[24]
- Another[25] found that non-smokers had a non-significant reduction in the odds of failure (OR=0.42 (95%CI: 0.12-1.24) on multivariate analysis)
- Sverzut (2008)[26] found no significant difference in risk of early failure in smokers compared to non-smokers (HR=1.2390; $p=0.5994$)
- Another study[27] found that the risk of failure was not significantly different for smokers compared to non-smokers (5.6% vs. 3.7%; $p=0.342$).

Of the 6 case series, 3 found that smoking adversely affected implant survival and the other 3 found no significant difference in survival in smokers compared to non-smokers:

- A small study[28] reported a significant difference in survival rates in smokers and non-smokers (75.8% vs. 97.7% respectively) but no statistics were given
- More implants failed in people who smoked compared to those who didn't ($p<0.001$) in another case series[29]
- A significant ($p<0.001$) difference in success rates between smokers & non-smokers (84.2% vs. 98.6%) was found in one study[30]. The authors also found a dose-response curve of relative risks: 6.5 light smoker; 8.5 moderate smoker; 21.8 heavy smoker
- Another small study[31] reported that smoking at least 20 cigarettes per day did not affect survival of dental implants placed in fully edentulous arches using a single-stage surgical protocol
- Lemmerman (2005)[32] found that there was no statistical difference between implant failure in smokers compared to non-smokers ($p=0.945$). In this study smokers were encouraged to quit and not sure whether they were still included in the smoking group
- Another smaller study[33] evaluating implants replacing a single molar between two natural teeth, reported that there no significant difference in failure/complication rates in smokers compared to non-smokers.

A consensus statement from the Academy of Osseointegration[34] and the nine non-systematic reviews[35-43] identified, have all concluded that smoking has an adverse effect on implant survival and success and two papers went on to state that this effect seems to be more pronounced in loose trabecular bone[34] and the maxilla[42].

While smoking is reported not to be an absolute contraindication to implant therapy[40], these people should be informed of the elevated risk[35, 36, 40] of implant complications and counselled to stop smoking[35, 36].

Discussion

Smoking is an established risk factor for periodontitis and delayed wound healing after tooth extraction[42]. The previous ACC Dental Implant Evidence-based Review (2004)[1] concluded that smoking as a single risk factor may not increase the risk of implant failure sufficiently to deny treatment but that dental implants may be contraindicated in smokers who have other relevant risk factors.

The evidence since 2004, reviewed above, supports these recommendations and strengthens the evidence base for smoking as a risk factor for dental implant failure. It seems reasonable to conclude that smoking does decrease the risk of implant survival by approximately 3%[12] with an RR of about 2[15, 16].

Moreover, there is some evidence of a dose-response relationship between smoking and risk of implant failure[6, 30] and a biologically plausible mechanism[12, 15, 16] for greater implant failure in smokers, which supports the conclusions above.

Therefore it is concluded that there is moderate evidence that smoking reduces implant survival but that the effect size is so small as not to be clinically relevant. However, when associated with other risk factors, it may become relevant.

Suggested Recommendations:
Smoking less than ten cigarettes per day as a single risk factor may not increase the risk of failure sufficiently to deny treatment.
Dental implants may be contra-indicted in smokers who have other relevant risk factors.

Table 2. Effect of smoking on dental implant failure.

Reference	LOE*	Description	Numbers		Key Results
			People	Implants	
Alsaadi G, Quirynen M, Komarek A & van Steenberghe D. 2007[6]	2+	Dental implant (Brånemark system®) survival and factors related to risk of early* failure. University setting. *early = before or up to abutment connection	2004	6946	Significant higher risk of implant failure in people who smoked 10-20cigs/day & >20cigs/day compared to non-smokers: OR = 1.90 & 2.18 respectively
Alsaadi G, Quirynen M, Komarek A & van Steenberghe D. 2008a[7]	2-	Dental implant (Brånemark system®) survival and factors related to risk of late* failure. University setting. *late = after occlusal loading is established	412	1514	No significant differences in incidence of late failures in smokers: p =0.28/adjusted p =1
Alsaadi G, Quirynen M, Michiles K, Teughels W, Komarek A & van Steenberghe D.	2-	Dental implant (MkII TiUnite™) survival and factors related to early* failure.	238	720	Smoking significantly increased the number of early failures compared to not smoking:

Table 2. Effect of smoking on dental implant failure.					
Reference	**LOE***	**Description**	**Numbers**		**Key Results**
			People	**Implants**	
2008b[8]		University setting. *early = before or up to abutment connection			5.56% vs. 1.12% respectively; p<0.001
Anitua E, Orive G, Aguirre J J, Ardanza B & Andia I. 2008[9]	2-	Dental implant (BTI®)* survival and factors related to failure. *Biotechnology Institute	1060	5787	Smoking significantly increased the number of failures compared to not smoking on univariate analysis (98.9% & 99.3% cumulative survival rate respectively p=0.013) but not on multivariate analysis.
Aykent F, Inan O, Ozyesil A G & Alptekin N O. 2007[28]	3	Clinical changes in peri-implant tissues and survival/success rates with respect to various factors. Calcitek & Straumann implants. University setting.	34	106	Cumulative survival rate in smokers (75.8%) reported as significantly (p<0.05) different from cumulative survival rate in non-smokers (97.7%).
DeLuca S, Habsha E & Zarb G A. 2006[19]	2+	Survival of Brånemark implants in relation to smoking. Brånemark implants. University setting.	464	1852	Significantly higher risk of early* implant failure for smoking at the time of implant placement (RR=1.69, p=0.05) and of late* implant failure for a positive smoking history (RR=1.16, p=0.030) compared to not smoking and a negative smoking history respectively [multivariate analysis]. *early = removed prior to prosthesis installation *late = removed after prosthesis installation
Hinode D, Tanabe S, Yokoyama M, Fujisawa K, Yamauchi E & Miyamoto Y. 2006[15]	2-	Systematic review of the effect of smoking on dental implant failure and influence of implant location on failure in smokers. (N=19 studies)	NR	17278	Odds of implant failure in smokers compared to non-smokers significantly increased: OR=2.17 (95%CI: 1.61-2.65) Range of ORs: 0.64-23.1
Holahan C M, Koka S, Kennel K A, Weaver A L, Assad D A, Regennitter F J & Kademani D. 2008[11]	2-	Effect of a diagnosis of osteoporosis or osteopenia in women 50yrs or over on the survival rate of osseointegrated dental implants. University setting.	192	646	Significantly higher risk of failure in smokers compared to non-smokers: HR = 2.6 (95%CI: 1.20-5.63), p=0.016
Kinsel R P & Liss M.	3	Effect of various factors on	43	344	No significant differences in failure rates

Table 2. Effect of smoking on dental implant failure.					
Reference	**LOE***	**Description**	**Numbers**		**Key Results**
			People	**Implants**	
2007[31]		the survival of Straumann dental implants placed in edentulous arches. Private practice.			between smokers (defined as at least 20cigs/day) compared to non-smokers. p=0.111
Klokkevold P R & Han T J. 2007[12]	2-	Systematic review of the effect of smoking, diabetes & periodontitis on the survival or success of dental implants. (N=14 studies)	1150	10904	Implant survival in smokers 89.7% (95%CI: 87-92.4%) compared to non-smokers 93.3% (95%CI: 91-95.6%). Significant difference in survival = 2.68% (95%CI: 1.1-4.26%) [p=0.0009]. Implant success in smokers 77% (95%CI: 66.1-87.9%) compared to non-smokers 91% (95%CI: 86.6-95.4%). Significant difference in success = 11.28% (95%CI: 3.41-19.15%) [p=0.005].
Kourtis S G, Sotiriadou S, Voliotis S & Challas A. 2004[29]	3	Associate the causes of dental implant failure with some potential risk factors. Various implant brands. Private dental clinics (4).	405	1692	Implant failures were significantly greater in smokers than non-smokers (p<0.001).
Lemmerman K J & Lemmerman N E. 2005[32]	3	Factors that affect the success or failure of dental implants. Various implant brands. Private periodontal clinic.	376	1003	Smoking does not affect failure rate (p=0.945)
Levin L, Laviv A & Schwartz-Arad D. 2006[33]	3	Long-term success & survival rates of dental implants replacing a single molar between two natural teeth and factors that may affect those rates. Screw-type implants (brand not reported) University setting.	81	81	No relation was found among failure, complications, timing of implant placement and smoking habits (no statistics reported).
McDermott N E, Chuang S-K, Woo V V & Dodson T B. 2003[17] NB included as this was not included in the previous review.	2+	Types and frequencies of complications associated with implants AND to identify risk factors associated with implant complications. Bicon dental implants.	677	677	Smokers have greater risk of overall complications compared with non-smokers. HR=2.31 (95%CI: 1.29-4.16) p=0.0051 [multivariate analysis] Smokers have a greater risk of inflammatory complications compared with

Table 2. Effect of smoking on dental implant failure.					
Reference	**LOE***	**Description**	**Numbers**		**Key Results**
			People	**Implants**	
		Hospital Dentistry Centre.			non-smokers HR=3.26 (95%CI: 1.74-6.10) p=0.0002 [multivariate analysis]
McDermott N E, Chuang S-K, Woo V V & Dodson T B. 2006[44]	2+	Investigation of maxillary sinus augmentation as an independent risk factor for implant failure using multivariate analysis. Bicon dental implants. Hospital Dentistry Centre.	677	2349	People who smoke have a greater risk of implant failure compared with non-smokers. HR=3.5 (95%CI: 1.7-7.2) p<0.001 [multivariate analysis]
Moheng P & Feryn J-M. 2005[20]	2-	Biomarkers of bone turnover as predictors of implant failure and other factors that may be related to failure. Frialit-2® or IMZ® Twin Plus dental implants. Hospital Dental Implantology Centre.	93	266	Implants in people who smoke are more likely to fail compared to non-smokers. RR=14.4, p<0.0001 [multivariate analysis]
Moy P K, Medina D, Shetty V & Aghaloo T L. 2005[21]	2-	Risk factors for implant failure. Various dental implant brands. University setting.	1140	4680	Smoking increased the risk of implant failure compared to non-smokers. RR=1.39, p=0.03 [stepwise logistic regression]
Mundt T, Mack F, Schwahn C & Biffar R. 2006[13]	2-	Potential risk factors for implant failure. Tiolox dental implants. Private practice.	159	663	Significant difference in survival rates between non-smokers and former smokers (p=0.036), non-smokers and current smokers (p<0.001), and former smokers and current smokers (p=0.003). Multifactorial Cox regression model considering 1 implant per patient showed significant association between duration of smoking and increased risk of implant failure (p=0.036). HR=1.04 (95%CI: 1.00-1.08) Cox regression model considering all implants showed smoking duration was significant (p=0.004). HR=1.04 (95%CI: 1.01-1.07) HRs for smoking duration in this model were 1.54 for 10 years, 2.36 for 20 years,

Table 2. Effect of smoking on dental implant failure.					
Reference	**LOE***	**Description**	**Numbers**		**Key Results**
			People	**Implants**	
					3.63 for 30 years, 5.58 for 40 years and 6.92 for 45 years.
Noguerol B, Munoz R, Mesa F, de Dios Luna J & O'Valle F. 2006[22]	2-	Determine accuracy of Periotest® to monitor primary implant stability and identify variables associated with **early** implant failure. Brånemark® dental implants. Single periodontal clinic	316	1084	Smoking >20cigs/day significantly increases risk of implant failure compared to smoking <20cigs/day. OR=2.50 (95%CI: 1.3-4.79)
Roos-Jansaker A M, Lindahl C, Renvert H & Renvert S. 2006[24]	2-	Investigate the long-term outcome of implant therapy and association between various factors and implant loss. Brånemark® dental implants Public Dental Health Service.	218	1057	No significant difference in implant loss when comparing people who have never smoked (6%) and those who are current or ex-smokers (12%) [p=0.16].
Sanchez-Perez A, Moya-Villaescusa M J & Caffesse R G. 2007[30]	3	Risk of smoking with regards to implant success. Type of implant not reported. Private dental practice.	66	165	Significant (p<0.001) difference in success rates between smokers (S) & non-smokers (NS) (84.2% vs. 98.6%) Significant (p<0.05) difference in failure rates between all smoking subgroups except medium smokers (MS) & heavy smokers (HS). Relative risk (no CIs) of failure of implant: RR [S vs. NS] = 11.2 RR [LS vs. NS] = 6.5 RR [MS vs. NS] = 8.5 RR [HS vs. NS] = 21.8
Sjostrom M, Sennerby L, Nilson H & Lundgren S. 2007[25]	2-	Implant stability in grafted maxillae and factors that affect risk of implant failure. Standard® and Mark II® Brånemark dental implants. University setting.	29	192	Non-smokers did not have significantly decreased odds of implant loss compared with smokers: OR=0.42 (95%CI: 0.12-1.24) [multivariate analysis]
Strietzel F P, Reichart P A, Kale A, Kulkarni M, Wegner B & Kuchler	2-	Systematic review of effect of smoking on implant survival (with or without	3383	16605	Risk of implant failure significantly greater in smokers compared to non-smokers. Implant-related failure OR=2.38 (95%CI:

Table 2. Effect of smoking on dental implant failure.					
Reference	**LOE***	**Description**	**Numbers**		**Key Results**
			People	**Implants**	
I. 2007[16]		sinus augmentation).			1.93-2.93) [random-effects model without covariates] Patient-related failure OR=2.64 (95%CI: 1.70-4.09) [fixed-effects model without covariates]
Susarla S M, Chuang S-K & Dodson T B. 2008[18]	2+	Risk factors for implant failure. Bicon dental implants. Private practice.	855	2826	Increased risk of failure in smokers compared to non-smokers. HR=2.6 (95%CI: 1.8-3.9) p<0.01 [multivariate analysis]
Sverzut A T, Stabile G A V, de Moraes M, Mazzonetto R & Moreira R W F. 2008[26]	2-	Tobacco use as a risk failure for early implant failure. Implant brand not reported. University setting.	650	1628	Tobacco use did not significantly change risk of early implant failure. HR=1.2390, p=0.5994 [univariate analysis]
Wagenberg B & Froum S J. 2006[27]	2-	Risk factors for implant failure.	891	1925	No significant association between smoking and implant failure. 5.6% (18/323) implants in smokers failed compared with 3.7% (59/1602) in non-smokers (p=0.342).
Woo V V, Chuang S-K, Daher S, Muftu A & Dodson T B. 2004[23]	2-	Assess the use of dentoalveolar reconstructive procedures as a risk factor for implant failure. Bicon dental implants. Hospital setting.	677	677	Increased risk of implant failure in smokers compared to non-smokers. HR=4.4 (95%CI: 2.0-9.8), p<0.001

*LOE = level of evidence

Effect of periodontitis

Nine papers[9, 12, 22, 27, 45-50] were found that referred to the effect of a history of periodontitis on implant failure, including 5 systematic reviews and 4 cohort studies (Table 3).

One consensus guideline[34] and 3 narrative reviews[39, 42, 43] also discussed periodontal health with respect to dental implants.

Of the 5 systematic reviews:

- Karoussis (2007)[47] found no statistically significant differences in both short-term and long-term implant survival in partially edentulous people with a history of chronic periodontitis compared to people without such a history. However,

significantly greater long-term probing pocket depth, peri-implant marginal bone loss and incidence of peri-implantitis were found in this group of people with periodontitis

- Another review[12] found that there was no significant difference in survival of implants placed in people who had a history of treated periodontitis but there was a significant difference in implant success rate (pooled difference in success rates = -11.05% (95%CI: -20.06 to -2.03%); p=0.0163) even though the pooled success rates were similar i.e. 89% vs. 89.2%

- Ong (2008)[48], in a narrative analysis, reported that all studies (N=5) except one, found that implant survival was better for the non-periodontitis group but that only two studies reported a statistically significant difference. Four of five studies reporting on implant success found that success was better in the non-periodontitis groups, but only one found a statistically significant difference

- The other two systematic reviews[49, 50] found no significant increase in implant failure in people with periodontitis-associated tooth loss at 5- and 10-yr follow-up. Nor was there a significant increase in suprastructure loss. However, the authors did find a significant increase in peri-implantitis & marginal bone loss (based on only one study each).

Of the 4 cohort studies:

- One study[9] found that 69.6% (16/23) of participants with failing implants had chronic or aggressive periodontitis but no statistics were reported

- Another[46] found that people with current manifestations or history of periodontitis had a significantly increased the risk of implant failure (RR=2.49 (95%CI: 1.03-6.02) over a mean follow-up period of almost 2yrs

- In a study[22] to identify variables associated with early implant failure, a non-significant increase in risk of failure was found in people with treated periodontitis compared to those who did not have periodontitis or who were edentulous. (OR=2.36 (95%CI: 0.9-6.21))

- Another study[27] found a significant difference in failure rates between implants placed in sites where teeth were removed due to periodontal disease and those placed in sites where teeth were removed for non-periodontal reasons (8.2% vs. 3.1%; RR=2.3; p=0.02).

The consensus based guideline[34] concluded that a history of treated periodontitis does not appear to adversely affect implant survival rates, but periodontitis may have a negative effect on implant success rates, particularly over longer periods. They recommended that a periodontal evaluation and appropriate treatment be provided to ensure people have the most optimal periodontal health possible[42] prior to implant placement. This is supported by Wood (2004)[42], who adds that preventative periodontal therapy should be maintained after implant placement.

One of the two other narrative reviews[39, 43] reported that chronic periodontitis was a risk factor for implant failure[39] and the other that people with a history of aggressive periodontitis had an increased risk of developing peri-implantitis[43] (which can result in implant failure).

Discussion

Periodontitis is one of the common causes of tooth loss and dental implants are being increasingly used to replace missing teeth in these people[48]. The same pathogens responsible for periodontitis have been implicated in peri-implant infections and implant loss[47]. Hence, it has been suggested that a history of past periodontitis may be an adverse prognostic factor for the survival of dental implants[48].

In the previous ACC dental implant review[1], the recommendation, based mainly on consensus opinion, was that people with periodontitis should be excluded as candidates for dental implants.

The evidence since 2004, reviewed above, suggests that although a history of treated periodontitis appears not to be a significant risk factor for implant failure, it may significantly affect implant success, especially over longer periods of time. There is also some suggestion that periodontitis present at the time of implant placement may increase the risk of failure to a greater extent, although this is not certain.

The consensus of opinion is that periodontitis at the time of implant placement reduces implant survival and any periodontitis present should be treated first (and consequently reduce the risk of further tooth loss) before consideration of implant therapy and also to continue preventative periodontitis therapy if the decision is made to use dental implants in that person.

Suggested evidence statement:
There is insufficient evidence that people with a history of treated periodontitis have a significantly elevated risk of implant failure.
There is a consensus view that people with periodontitis must be treated for this condition before being considered for implant therapy.
There is a consensus view that preventative therapy for periodontitis should continue after the placement of implants in people with a history of periodontitis.

Table 3. Effect of periodontitis on dental implant failure.

Reference	LOE*	Description	Numbers		Key Results
			People	Implants	
Anitua E, Orive G, Aguirre J J, Ardanza B & Andia I. 2008[9]	2-	Dental implant (BTI®)* survival and factors related to failure. *Biotechnology Institute	1060	5787	69.6% (16/23) of participants with failing implants had chronic or aggressive periodontitis
Evian C I, Emling R, Rosenberg E S, Waasdorp J A, Halpern W, Shah S & Garcia M. 2004[46]	2-	Dental implant survival and effect of periodontal disease & immediate implant placement after tooth extraction on long-term survival Private practice setting.	149	149	Global survival rate = 85.2% Periodontitis significantly increased the risk of implant failure (RR=2.49 (95%CI: 1.03-6.02))

Table 3. Effect of periodontitis on dental implant failure.					
Reference	**LOE***	**Description**	**Numbers**		**Key Results**
			People	**Implants**	
Karoussis I K, Kotsovilis S & Fourmousis I. 2007[47]	2-	Systematic review of prospective studies regarding the short- & long-term prognosis of dental implants placed in periodontally compromised partially edentulous patients. (N=15 studies)			Short-term (7 studies) and long-term (6 studies) survival rate in people with a history of chronic periodontitis similar to general population. Short-term survival in people with a history of aggressive periodontitis was approximately 95-100% (2 studies) & long-term survival was 88.8% (1 study).
Klokkevold P R & Han T J. 2007[12]	2-	Systematic review of the effect of smoking, periodontitis & diabetes on implant survival & success. (N=13 studies)	1150	10904	Implant survival in people with a history of treated periodontitis [95% (95%CI: 91.8-98.2%)] compared to people without such a history [97.1% (95%CI: 94.8-99.4%)]. No significant difference in survival = -3.14% (95%CI: -6.97 to 0.68%) [p=0.1075]. Implant success in people with a history of treated periodontitis [89% (95%CI: 82.3-95.7%)] compared to people without such a history [89.2% (95%CI: 81.2-97.2%)]. Significant difference in success = -11.05% (95%CI: -20.06 to -2.03%) [p=0.0163].
Noguerol B, Munoz R, Mesa F, de Dios Luna J & O'Valle F. 2006[22]	2-	Determine accuracy of Periotest® to monitor primary implant stability and identify variables associated with **early** implant failure. Brånemark® dental implants. Single periodontal clinic	316	1084	Non-significant increase in risk of failure in people with treated periodontitis compared to those who were did not have periodontitis or were edentulous. OR=2.36 (95%CI: 0.9-6.21)
Ong C T T, Ivanovski S, Needleman I G, Retzepi M, Moles D R, Tonetti M S & Donos N. 2008[48]	2-	Systematic review to determine the effect of a history of periodontitis on survival & success of dental implants in partially dentate people. (N=9 studies)			Four of 5 studies reported better implant survival for the non-periodontitis group, however only 2 studies reported a statistically significant difference. Four of 5 studies reported better implant success for the non-periodontitis group, however only one found a statistically significant difference.
Schou S. 2008[49]	2-	Systematic review of the outcomes of dental implant treatment in periodontally-susceptible			No significant increase of risk of implant or suprastructure failure in people with periodontitis-associated tooth loss. Significant increased risk of peri-implantitis

Table 3. Effect of periodontitis on dental implant failure.					
Reference	**LOE***	**Description**	**Numbers**		**Key Results**
			People	**Implants**	
		patients. (N=23 studies)			& peri-implant bone loss in people with periodontitis-associated tooth loss. For RRs & WMD – see Shou 2006 below
Schou S, Holmstrup P, Worthington H V & Esposito M. 2006[50]	2-	Systematic review of the outcomes of dental implant treatment in periodontally-susceptible patients. (N=2 studies)			No significant increase in risk of implant loss in people with periodontitis-associated tooth loss at 5- & 10-yr follow-up: RR=2.24 (0.71-7.04) at 5yr follow-up (both studies) RR=3.75 (0.74-19.02) at 10yr follow-up (Hardt 2002) No significant increase in risk of suprastructure failure in people with periodontitis-associated tooth loss: RR=5.00 (95% CI: 0.25-99.16) at 5yr follow-up (Hardt 2002) Significant increase risk of peri-implantitis & marginal bone loss in people with periodontitis-associated tooth loss: RR=9.00 (3.94-20.57) at 10yr follow-up (Karoussis 2003) WMD=0.50 (0.06-0.94) at 5yr follow-up (Hardt 2002)
Wagenberg B & Froum S J. 2006[27]	2-	Risk factors for implant failure.	891	1925	A significant difference in failure rates between implants placed in sites where teeth were removed due to periodontal disease and those placed in sites where teeth were removed for non-periodontal reasons (8.2% vs. 3.1%; RR=2.3; p=0.02)

**LOE = level of evidence*

Effect of oral hygiene/habits

Three papers[13, 29, 45] were reviewed that evaluated the effect of oral hygiene/habits on implant survival/success (Table 4). Two narrative reviews[39, 43] are also included.

- The single case-control study[45] found no significant differences in any of the oral hygiene habits e.g. frequency of brushing, mouth washing, & flossing, between people who had at least one dental implant failure and those who had no implant failures
- The only cohort study[13] also reported that oral health behaviour e.g. frequency of tooth brushing, use of other oral hygiene products, last dental appointment and

reason for the last appointment, had no significant effect on implant failure but no statistics were reported

- The case series[29] found significant differences in failure rates between the 'good-medium' group & 'insufficient' oral hygiene group ($p<0.001$). The evaluation of oral hygiene was a subjective assessment during each recall appointments.

Of the narrative reviews, one[43] concludes that pathologic findings in the oral tissues are temporary contraindications to implant placement due to an increased risk of infection and that implant placement should be delayed until resolution of the intra-oral pathology. The other[39] lists unresolved caries, endodontic lesions & frank pathology as risk factors for implant loss.

Discussion

Only one of the above studies looked at the oral health status and found that the group with a subjectively assessment of 'insufficient' oral hygiene had a greater failure rate[29]. The other two studies[13, 45] investigated oral hygiene behaviours and found these not to affect outcome.

However, as stated in the last review[1], dental opinion seems to favour excluding people with poor oral hygiene, infection or uncontrolled caries from dental implant treatment.

Suggested evidence statement:
There is a consensus of opinion that people with poor oral hygiene, infection or uncontrolled caries should not be offered dental implants.

Table 4. Effect of oral hygiene/habits on dental implant failure.

Reference	LOE*	Description	Numbers		Key Results
			People	Implants	
Alvim-Pereira F, Montes C C, Thome G, Olandoski M & Trevilatto P C. 2008[45]	2-	Relationship between vitamin D receptor gene polymorphism & other clinical factors with dental implant failure. NEODENT™ implants University setting.	217	1376	No significant difference in oral hygiene habits e.g. frequency of brushing [1-3X daily vs. >3X daily], flossing daily [Y/N] & mouth washing daily [Y/N], between the 2 groups (p=0.744, 0.495, 0.575). Unadjusted OR = 1.18 (95%CI: 0.62-2.26) Unadjusted OR = 0.79 (95%CI: 0.41-1.53) Unadjusted OR = 0.84 (95%CI: 0.48-1.46) respectively
Kourtis S G, Sotiriadou S, Voliotis S & Challas A. 2004[29]	3	Report the survival of dental implants and associate the causes of failure with some potential risk factors. Variety of implant brands. Private practices (4).	405	1692	Significant difference in failure rates between 'good-medium', and 'insufficient' oral hygiene p<0.001 Failure rates: 2.5% in 'good' group, 2.9% in 'medium' group, & 13.8% in the 'insufficient' group
Mundt T, Mack F, Schwahn C & Biffar R. 2006[13]	2-	Potential risk factors for implant failure.	159	663	Oral health behaviour reported as having no significant effect on implant failure.

Table 4. Effect of oral hygiene/habits on dental implant failure.					
Reference	LOE*	Description	Numbers		Key Results
			People	Implants	
		Tiolox dental implants. Private practice.			

**LOE = level of evidence*

Effect of location

Twenty-six papers were reviewed that evaluated the effect of location on implant survival/success, including 16 cohort studies, one case-control, six case series & three narrative reviews (Table 5).

Of the 5 cohort studies considered to have a low risk of confounding, bias or chance,

- Two[18, 19] found a significantly greater risk of implant failures if implants were placed in maxilla
- McDermott (2003)[17], however, found no association between location of implants in maxilla or mandible and complications in a smaller study
- Another[6] found a significantly greater risk of early failure in posterior region of the mandible and maxilla compared to anterior region of the mandible and maxilla (OR = 1.81) on multivariate analysis
- McDermott (2006)[44] found a higher risk of failure of implants placed in a molar location compared to pre-molar location in a group of people who had implants placed in the posterior maxilla.

Of the 11 cohort studies considered to have a high risk of confounding, bias or chance, 4 found a significant effect of location:

- Two[21, 51] found an increased risk of implant failure in the maxilla compared to the mandible
- Alsaadi (2008a)[7] found a greater risk of late failure in all regions of the maxilla and the posterior mandible compared to the anterior mandible on multivariate analysis
- Sverzet (2008)[26] found that 'Location 3' (defined as: "maxillary anterior, maxillary posterior, mandibular anterior, and mandibular posterior) had a hazard ratio of 0.3900 (p=0.0023) on multivariate analysis but which actual location had the greater (or lesser) risk was not reported.

The remaining 7 studies[8, 9, 11, 20, 22, 24, 25, 52, 53] found no significant association between the risk of failure and location.

- Three studies[25, 52, 53] were of a small sample i.e. 35, 39 & 29 participants respectively
- No statistics were reported in two other studies[11, 24]
- One study compared a limited number of locations (anterior only) in people with a grafted edentulous maxilla.

The only case-control study[45] also found that location had no effect on implant failure on multivariate analysis.

Of the case series,

- Kourtis (2004)[29] found that more implants failed in the maxilla compared to the mandible but no significant differences between posterior and anterior regions was found
- A smaller study[28] found a better success rate of implants placed in the mandible compared to the maxilla but no statistics were reported
- The four other case series[10, 30-32] found no association between implant location and risk of failure.

Of the 3 narrative reviews,

Paquette (2006)[38] reported that according to one study, the location of the implant (either maxilla vs. mandible or anterior vs. posterior) did not alter implant survival significantly. Another study in the review was reported as showing that placement in the maxilla increased the risk of implant failure on multivariate analysis.

Another[54], states that implant location plays an important role in implant success and that the cumulative survival rate of implants in the mandible seem to be slightly higher than in the maxilla – about a 4% difference. The success rate of implants in the anterior region seems to be higher than in the posterior regions of the jaws, mostly due to the quality of bone: about 12% difference between the anterior maxilla and posterior maxilla, and about 4% difference between anterior mandible and posterior mandible. NB: three of the six papers used in this narrative review have been included in this or the previous dental implant review.

The other narrative review[39] states that most authors agree that mandibular implants have a greater chance for success than those placed in the maxilla. The posterior maxilla is cited in a table of predictors of implant success or failure to be particularly prone to implant failure.

Discussion

Implant location has been on of the factors identified that may influence the success or failure of the dental implant[54]. In the last review[1], the conclusions reached were that the failure rate of implants in the edentulous maxilla may be higher than the mandible and this may be of clinical significance and a relevant patient selection factor. There was, however, inadequate evidence to conclude that implant failure was greater at posterior locations compared to anterior.

Taking this into consideration and adding the more recent evidence, there is some evidence that dental implants are at greater risk of failure when placed in the maxilla and weaker, conflicting evidence suggesting that in a posterior position implants may also have a greater risk.

The relevance of these findings is unclear. It may be that position/location ***per se*** is not a risk factor but that it may be confounded by other factors such as occlusal forces, blood supply, bone quality and quantity and/or the presence of a bone graft. A consensus opinion is needed as to any recommendation stemming from this evidence.

Suggested evidence statement:
There is weak evidence that dental implants placed in the maxilla may have a greater risk of failure
There is insufficient evidence that dental implants placed in the posterior region of a jaw have a greater risk of failure than those placed in the anterior region.

Table 5. Effect of location on dental implant failure.

Reference	LOE*	Description	Numbers		Key Results
			People	Implants	
Alsaadi G, Quirynen M, Komarek A & van Steenberghe D. 2007[6]	2+	Dental implant (Brånemark system®) survival and factors related to risk of early* failure. University setting. *early = before or up to abutment connection	2004	6946	On univariate analysis, there was significantly more risk of early failure in mandibular & maxillary posterior regions compared to the anterior mandible: • OR [posterior mandible vs. anterior mandible] = 1.99 (1.29-3.07) • OR [posterior maxilla vs. anterior mandible] = 1.88 (1.196-2.940) On multivariate analysis, significantly greater risk of early failure in posterior region: • OR [posterior] = 1.81 (95%CI: 1.30-2.53)
Alsaadi G, Quirynen M, Komarek A & van Steenberghe D. 2008a[7]	2-	Dental implant (Brånemark system®) survival and factors related to risk of late* failure. University setting. *late = after occlusal loading is established	412	1514	On univariate analysis, there was a greater risk of late failure of implants in the maxilla & posterior regions: • OR [maxilla vs. mandible] = 2.59 (1.50-4.49) • OR [posterior vs. anterior] = 2.14 (1.427-3.208) On multivariate analysis, greater risk of late failure in all other regions compared to anterior mandible: • OR [posterior mandible vs. anterior mandible] = 3.86 (1.41-10.54) • OR [anterior maxilla vs. anterior mandible] = 3.9 (1.49-10.22) • OR [posterior maxilla vs. anterior mandible] = 7.1 (2.69-18.78)
Alsaadi G, Quirynen M, Michiles K, Teughels W, Komarek A & van Steenberghe D.	2-	Dental implant (MkII TiUnite™) survival and factors related to early* failure.	238	720	Location had no effect on early implant failure rate: Anterior mandible 0.65% Posterior mandible 2.82% Anterior maxilla 2.16% Posterior maxilla 1.97%

Table 5. Effect of location on dental implant failure.					
Reference	**LOE***	**Description**	**Numbers**		**Key Results**
			People	**Implants**	
2008b[8]		University setting. *early = before or up to abutment connection			p=0.54 (Fisher); 0.59 (GEE*) *Generalised estimating equation
Alvim-Pereira F, Montes C C, Thome G, Olandoski M & Trevilatto P C. 2008[45]	2-	Relationship between vitamin D receptor gene polymorphism & other clinical factors with dental implant failure. NEODENT™ implants University setting	217	1376	On univariate analysis, there were significantly more implants lost in the mandible* (63%) than in the maxilla (49%) [p=0.003], and more implants were lost in the posterior† (65%) than the anterior region (55%) [p=0.037]. *Unadjusted OR = 0.57 (95%CI: 0.39-0.82) †Unadjusted OR = 0.66 (95%CI:0.46-0.96) This was not supported on Kaplan-Meier survival curve analysis.
Anitua E, Orive G, Aguirre J J, Ardanza B & Andia I. 2008[9]	2-	Dental implant (BTI®)* survival and factors related to failure. *Biotechnology Institute	1060	5787	Significantly more failures in the maxilla compared to mandible [p=0.031] on an implant-based analysis only but this was not found on multivariate analysis. No significant difference in posterior compared to anterior localisation.
Aykent F, Inan O, Ozyesil A G & Alptekin N O. 2007[28]	3	Clinical changes in peri-implant tissues and survival/success rates with respect to various factors. Calcitek & Straumann implants. University setting.	34	106	Significant difference reported between the cumulative success rates of implants in the mandible (92.2%) compared to the maxilla (87.0%). No statistics recorded.
Degidi M, Piattelli A, Gehrke P, Felice P & Carinci F. 2006[10]	3	Survival rate & bone loss of immediate non-functional single implant restorations over a 5yr follow-up period.	111	111	No significant difference in 5yr survival between implants placed in the mandible (100%) vs. the maxilla (94.6%)
DeLuca S, Habsha E & Zarb G A. 2006[19]	2+	Survival of Brånemark implants in relation to smoking. Brånemark implants. University setting.	464	1852	Significantly more failures on multivariate analysis if the implants were placed in the maxilla: • early failures RR [mandible vs. maxilla] = 0.56 p=0.030 • late failures RR [maxilla vs. mandible] = 2.38 p=0.004
Elkhoury J S, McGlumphy E A,	2-	Clinical parameters associated with long-term	39	39	No significant difference in implant success or failure according to implant

Table 5. Effect of location on dental implant failure.					
Reference	**LOE***	**Description**	**Numbers**		**Key Results**
			People	**Implants**	
Tatakis D N & Beck F M. 2005[52]		(5yr) success or failure of single tooth implants.			placement location [p=0.4304].
Gentile M A, Chuang S-K & Dodson T B. 2005[53]	2-	Survival of Bicon implants and risk factors associated with implant failure. Bicon 6x5.7mm dental implants. Hospital setting.	35	172	No significant differences in implant failure for implant location: HR [posterior vs. anterior] = 0.8 (95%CI: 0.2-2.9) p=0.70 HR[mandible vs. maxilla] = 0.5 (95%CI: 0.1-1.6) p=0.20
Herrmann I, Lekholm U, Holm S & Kultje C. 2005[51]	2-	Influence of some patient & implant characteristics on implant survival.	487	487	Reported a 'significant difference' between implant failures in the maxilla compared to the mandible. Analysis in another paper by authors.
Holahan C M, Koka S, Kennel K A, Weaver A L, Assad D A, Regennitter F J & Kademani D. 2008[11]	2-	Effect of a diagnosis of osteoporosis or osteopenia in women 50yrs or over on the survival rate of osseointegrated dental implants. University setting.	192	646	No significant association between arch location (anterior maxilla vs. posterior maxilla vs. anterior mandible vs. posterior mandible) and implant failure but no statistics were given.
Kinsel R P & Liss M. 2007[31]	3	Effect of various factors on the survival of Straumann dental implants placed in edentulous arches. Private practice.	43	344	Significant higher rates of failure for implants placed in the posterior quadrant (p=0.001) on univariate analysis but not on multivariate analysis.
Kourtis S G, Sotiriadou S, Voliotis S & Challas A. 2004[29]	3	Associate the causes of dental implant failure with some potential risk factors. Various implant brands. Private dental clinics (4).	405	1692	More implants failed in the maxilla than the mandible (72% vs. 28% of total failures; p<0.001). No significant differences in failure rates of implants in the posterior (4.4%) vs. the anterior (4.2%) region.
Lemmerman K J & Lemmerman N E. 2005[32]	3	Factors that affect the success or failure of dental implants. Various implant brands. Private periodontal clinic.	376	1003	No significant differences in failure rates of implants in different locations (p=0.127).

Table 5. Effect of location on dental implant failure.					
Reference	**LOE***	**Description**	**Numbers**		**Key Results**
			People	**Implants**	
McDermott N E, Chuang S-K, Woo V V & Dodson T B. 2003[17]	2+	Types and frequencies of complications associated with implants AND to identify risk factors associated with implant complications. Bicon dental implants. Hospital Dentistry Centre.	677	677	No association between location of implants in the maxilla or mandible and overall[*] & inflammatory[†] complications. [*]no results reported [†]HR [maxilla vs. mandible] = 0.65 (95%CI: 0.38-1.09) p=0.10
McDermott N E, Chuang S-K, Woo V V & Dodson T B. 2006[44]	2+	Investigation of maxillary sinus augmentation as an independent risk factor for implant failure using multivariate analysis. Bicon dental implants. Hospital Dentistry Centre.	677	2349	Higher risk of implant failure in molar location compared to premolar location on multivariate analysis. HR [premolar vs. molar] = 0.4 (95%CI: 0.2-0.6) p<0.001
Moheng P & Feryn J-M. 2005[20]	2-	Biomarkers of bone turnover as predictors of implant failure and other factors that may be related to failure. Frialit-2® or IMZ® Twin Plus dental implants. Hospital Dental Implantology Centre.	93	266	Implant location is not a significant risk factor for implant failure (p=0.90).
Moy P K, Medina D, Shetty V & Aghaloo T L. 2005[21]	2-	Risk factors for implant failure. Various dental implant brands. University setting.	1140	4680	Increased risk of implant failure in the maxilla compared to the mandible. RR = 1.79 (p=0.001) stepwise logistic regression
Noguerol B, Munoz R, Mesa F, de Dios Luna J & O'Valle F. 2006[22]	2-	Determine accuracy of Periotest® to monitor primary implant stability and identify variables associated with **early** implant failure. Brånemark® dental implants. Single periodontal clinic	316	1084	Location of implant placement not associated with an increased risk of early failure on multivariate analysis (no figures reported).
Roos-Jansaker A M, Lindahl C, Renvert H & Renvert S.	2-	Investigate the long-term outcome of implant therapy and association between various factors	218	1057	No relationship between implant location and implant loss (no statistics reported).

Table 5. Effect of location on dental implant failure.					
Reference	**LOE***	**Description**	**Numbers**		**Key Results**
			People	**Implants**	
2006[24]		and implant loss. Brånemark® dental implants Public Dental Health Service.			
Sanchez-Perez A, Moya-Villaescusa M J & Caffesse R G. 2007[30]	3	Risk of smoking with regards to implant success. Type of implant not reported. Private dental practice.	66	165	No significant difference in success in regard to location of implant (p>0.05).
Sjostrom M, Sennerby L, Nilson H & Lundgren S. 2007[25]	2-	Implant stability in grafted maxillae and factors that affect risk of implant failure. Standard® and Mark II® Brånemark dental implants. University setting.	29	192	No significant difference on multivariate analysis in failure of implants in the 2nd premolar, canine & lateral incisor position compared to the central incisor position in people with grafted edentulous maxillae: OR = 2.05 (95%CI: 0.69-6.12)
Susarla S M, Chuang S-K & Dodson T B. 2008[18]	2+	Risk factors for implant failure. Bicon dental implants. Private practice.	855	2826	Significant increase in failures in maxilla compared to mandible on multivariate analysis. HR = 1.9 (95%CI: 1.3-2.9) p<0.001
Sverzut A T, Stabile G A V, de Moraes M, Mazzonetto R & Moreira R W F. 2008[26]	2-	Tobacco use as a risk failure for early implant failure. Implant brand not reported. University setting.	650	1628	Significant association between implant failure and 'location 3" i.e. anterior mandible, posterior mandible, anterior maxilla & posterior maxilla. HR = 0.3900 p=0.0023 NB: not enough information reported to distinguish regions with better (or worse) outcomes.

*LOE = level of evidence

Effect of bone quality

Seventeen papers were reviewed that evaluated the effect of bone quality on implant survival/success, including eight cohort studies, one case-control, four case series and four narrative reviews. (Table 6).

Of the cohort or case-control studies,

- Four studies[6, 8, 20, 53] found that bone quality was not significantly related to early implant failure
- Alvim-Pereira (2008)[45] found no difference in implant survival according to bone quality
- In contrast, Alsaadi (2008a)[7] found a significantly greater risk of late implant failure in bone quality grade 4 when compared to grade 2 (OR = 3.92 (95%CI: 1.51-10.21)) on univariate analysis
- Another study[51] found a significant difference in failure rates between all bone types and also when comparing types 1, 2 & 3 together to type 4 ($p<0.001$)
- Whereas Noguerol (2006)[22] found a greater risk of early implant failure in bone types 1, 3 & 4 together compared to type 2 (OR=1.93)
- And Elkhoury (2005)[52] found that the mean bone quality in people with a failed implant significantly different from mean bone quality in those with a successful implant (2.90 vs. 1.79 respectively; $p<0.001$).

Of the 4 case series,

- One[10] found a significant difference in 5yr survival between type 1 (100%) and type 4 (95.5%) bone ($p<0.05$)
- Another[29] found a significantly higher failure rate in type 4 bone compared to the other types ($p<0.001$)
- However, Lemmerman (2005)[32] and Sanchez-Perez (2007)[30] found no significant difference in failure rates and success rates respectively according to bone type.

Of the narrative reviews:

There appears to be a consensus that good bone quality (and adequate bone quantity) are essential for implant success[39, 42] and that poor bone quality (type 4) is a significant determinant for implant failure[38, 39, 41].

Discussion

As stated in the last review[1], the evidence for bone quality affecting implant success is not strong. This is perhaps not surprising when you consider that often people with poor bone quality are not included in a study[30], the effect of bone quality on implant failure is usually a secondary goal, and there appears to be a complex relationship between factors; for example, bone quantity, bone quality, type of edentulism, & smoking. Often studies do not have sufficient power to detect differences in success/failure according to bone quality[7] and can use different criteria or combinations of criteria for quality, making it difficult to compare studies.

The more recent evidence is conflicting, with seven of the thirteen observational studies finding no significant association between bone quality and failure. Even amongst the other studies that did find a significant association the results are conflicting i.e. more failures in type 4 compared to type 2[7]; more failures in type 4 compared to types 1, 2 & 3 combined[51]; more failures in types 1, 3 & 4 combined compared to type 2[22].

However, there is a strong consensus from the narrative reviews that bone quality is an important determinant for implant success.

Suggested evidence statement:
There is conflicting evidence that bone quality has a significant effect on the risk of implant failure.

Table 6. Effect of bone quality on dental implant failure.

Reference	LOE*	Description	Numbers		Key Results
			People	Implants	
Alsaadi G, Quirynen M, Komarek A & van Steenberghe D. 2007[6]	2+	Dental implant (Brånemark system®) survival and factors related to risk of early* failure. University setting. *early = before or up to abutment connection	2004	6946	Bone quality not significantly related to implant failure on multivariate analysis: OR [grade 2 vs. grade 1] = 0.56 (0.29-1.05) OR [grade 3 vs. grade 1] = 0.82 (0.46-1.47) OR [grade 4 vs. grade 1] = 1.04 (0.53-2.07)
Alsaadi G, Quirynen M, Komarek A & van Steenberghe D. 2008a[7]	2-	Dental implant (Brånemark system®) survival and factors related to risk of late* failure. University setting. *late = after occlusal loading is established	412	1514	Significantly more loss in bone quality grade 4 when compared to grade 2 on univariate analysis: OR = 3.92 (95%CI: 1.51-10.21)
Alsaadi G, Quirynen M, Michiles K, Teughels W, Komarek A & van Steenberghe D. 2008b[8]	2-	Dental implant (MkII TiUnite™) survival and factors related to early* failure. University setting. *early = before or up to abutment connection	238	720	No significant difference in risk of implant failures according to bone quality on univariate analysis (p=0.73 Fisher).
Alvim-Pereira F, Montes C C, Thome G, Olandoski M & Trevilatto P C. 2008[45]	2-	Relationship between vitamin D receptor gene polymorphism & other clinical factors with dental implant failure. NEODENT™ implants University setting	217	1376	No significant difference in risk of implant survival according to bone quality (poor/good). [p=0.671] Unadjusted OR = 0.89 (95%CI:0.52-1.52) Not supported on Kaplan-Meier survival curve analysis. NB reported “good” quality as being = type B + C & “poor” quality as being type A + D
Degidi M, Piattelli A, Gehrke P, Felice P	3	Survival & bone loss over time of immediate non-	111	111	Significant difference (p<0.05) in survival

Table 6. Effect of bone quality on dental implant failure.					
Reference	**LOE***	**Description**	**Numbers**		**Key Results**
			People	**Implants**	
& Carinci F. 2006[10]		functional single implant restorations. Various implant brands Setting not stated.			at 5yrs between: Bone quality D1 (100%) vs. D4 (95.5%)
Elkhoury J S, McGlumphy E A, Tatakis D N & Beck F M. 2005[52]	2-	Clinical parameters associated with long-term (5yr) success or failure of single tooth implants.	39	39	Significant difference in mean bone quality between people with a failed implant compared with people with a successful implant (2.90 compared to 1.79; p<0.001).
Gentile M A, Chuang S-K & Dodson T B. 2005[53]	2-	Survival of Bicon implants and risk factors associated with implant failure. Bicon 6x5.7mm dental implants. Hospital setting.	35	172	No significant difference in failure rates according to bone quality: HR = 1.4 (95%CI:0.5-3.7) p=0.50
Herrmann I, Lekholm U, Holm S & Kultje C. 2005[51]	2-	Influence of some patient & implant characteristics on implant survival.	487	487	Significant difference in implant failures between all bone types (p<0.001) and between bone type 1+2+3 vs. bone type 4 (p<0.001).
Kourtis S G, Sotiriadou S, Voliotis S & Challas A. 2004[29]	3	Associate the causes of dental implant failure with some potential risk factors. Various implant brands. Private dental clinics (4).	405	1692	Statistically significant higher failure rate in type IV bone (p<0.001) compared to other types.
Lemmerman K J & Lemmerman N E. 2005[32]	3	Factors that affect the success or failure of dental implants. Various implant brands. Private periodontal clinic.	376	1003	No significant difference in failure rates with respect to bone type (p=0.539).
Moheng P & Feryn J-M. 2005[20]	2-	Biomarkers of bone turnover as predictors of implant failure and other factors that may be related to failure. Frialit-2® or IMZ® Twin Plus dental implants. Hospital Dental Implantology Centre.	93	266	No significant difference in failure rates with respect to bone type (p=0.25).
Noguerol B, Munoz R, Mesa F, de Dios	2-	Determine accuracy of Periotest® to monitor	316	1084	Greater risk of failure of implant in types I, III & IV bone compared to type II:

Table 6. Effect of bone quality on dental implant failure.					
Reference	**LOE***	**Description**	**Numbers**		**Key Results**
			People	**Implants**	
Luna J & O'Valle F. 2006[22]		primary implant stability and identify variables associated with early implant failure. Brånemark® dental implants. Single periodontal clinic			OR = 1.93 (95%CI: 1.01-3.7)
Sanchez-Perez A, Moya-Villaescusa M J & Caffesse R G. 2007[30]	3	Risk of smoking with regards to implant success. Type of implant not reported. Private dental practice.	66	165	No significant difference among bone quality and success rates (p>0.05).

**LOE = level of evidence*

Effect of bone quantity

Nine papers were reviewed that evaluated the effect of bone quantity on implant survival/success, including four cohort studies, one case-control & four narrative reviews (Table 7).

- Two of the cohort studies[6, 8] found that bone quantity was not related to early implant failure on multivariate analysis
- The other[8] found that bone quantity was not related to late implant failure
- The case-control study[45] found no significant difference in survival when comparing 'good' bone quantity [types B & C] and 'bad' bone quality [types A & D] (p=0.445) but that bone quantity was related to implant survival over time (p=0.049)
- The other study[51] found a significant difference in implant failures by jaw shape [group A+B+C vs. group D+E](p<0.001).

Paquette et al (2006)[38], in their narrative review, list a resorbed jaw (i.e. poor bone quantity) and combinations of jaw-bone related characteristics (i.e. combinations of bone quality and quantity) as being significant determinants for implant failure. Porter and von Fraunhofer (2005)[39] state that bone quantity is an essential consideration in implant success (with bone quality) and Torabinejad and Goodacre (2006)[41] conclude that the quantity of available bone affects the feasibility of placing implants without bone grafting.

Discussion

The evidence for bone quantity, surprisingly, appears even weaker than for bone quality. This may be due, in part, to selection bias whereby people with inadequate bone quantity

have bone grafting procedures to correct the bone deficiency and are not included in the studies. Moreover, all the studies except one have been assessed as having a high risk of bias, confounding or chance i.e. internal validity of the studies is poor, which limits the ability to make any firm conclusions.

And again there is a strong consensus that bone quantity is essential for dental implant success[38, 39, 41, 42] in the narrative review literature.

Suggested evidence statement:
There is conflicting evidence that bone quantity has a significant effect on the risk of implant failure.

Table 7. Effect of bone quantity on dental implant failure.

Reference	LOE*	Description	Numbers		Key Results
			People	Implants	
Alsaadi G, Quirynen M, Komarek A & van Steenberghe D. 2007[6]	2+	Dental implant (Brånemark system®) survival and factors related to risk of early* failure. University setting. *early = before or up to abutment connection	2004	6946	Bone quantity not significantly related to early implant failure on multivariate analysis: OR [grade B vs. grade A] = 0.64 (0.40-1.02) OR [grade C vs. grade A] = 0.86 (0.51-1.46) OR [grade D vs. grade A] = 0.95 (0.44-2.06) OR [grade E vs. grade A] = 2.00 (0.77-5.21)
Alsaadi G, Quirynen M, Komarek A & van Steenberghe D. 2008a[7]	2-	Dental implant (Brånemark system®) survival and factors related to risk of late* failure. University setting. *late = after occlusal loading is established	412	1514	No significant difference in risk of late implant failure according to bone quantity on univariate analysis (p=0.34/adjusted p=1).
Alsaadi G, Quirynen M, Michiles K, Teughels W, Komarek A & van Steenberghe D. 2008b[8]	2-	Dental implant (MkII TiUnite™) survival and factors related to early* failure. University setting. *early = before or up to abutment connection	238	720	No significant difference in risk of early implant failures according to bone quantity on univariate analysis (p=0.46 Fisher).

Table 7. Effect of bone quantity on dental implant failure.					
Reference	**LOE***	**Description**	**Numbers**		**Key Results**
			People	**Implants**	
Alvim-Pereira F, Montes C C, Thome G, Olandoski M & Trevilatto P C. 2008[45]	2-	Relationship between vitamin D receptor gene polymorphism & other clinical factors with dental implant failure. NEODENT™ implants University setting	217	1376	No significant difference in survival when comparing 'good' bone quantity vs. 'poor' bone quantity (p=0.445). NB: 'good' quantity = type B + C 'poor' quantity = type A + D Unadjusted OR = 1.27 (95%CI: 0.68-2.36) On Kaplan-Meier survival curve analysis, bone quantity was related to implant survival over time (p=0.049).
Herrmann I, Lekholm U, Holm S & Kultje C. 2005[51]	2-	Influence of some patient & implant characteristics on implant survival.	487	487	Significant difference in implant failures by jaw shape* (=quantity): group A+B+C vs. group D+E (p<0.001). *Lekholm & Zarb index

**LOE = level of evidence*

Effect of bone grafts/augmentation

Eleven papers were reviewed that evaluated the effect of bone graft/augmentation on implant survival/success, including three systematic reviews, seven cohort, one case-control study, two case series, a narrative review and one consensus guideline (Table 8).

Of the systematic reviews,

- One[3] found no significant difference in implant or prosthesis failure rates or major complication rates after bone augmentation compared to no augmentation [based on 2 studies]
- Whereas Strietzel (2007)[16] reported that the odds ratio was 2.15 for smokers without sinus floor augmentation procedures and 3.16 for smokers with augmentation which were significantly different (p=0.039) suggesting that augmentation procedure is a risk factor for implant loss
- Graziani (2004)[55] stated that the results suggest that the range of survival rates is greater in those who had sinus floor augmentation (36-100%) than those who did not (73-100%) on a per patient basis [2 studies] and that survival varied between 75 and 100% for both augmented and non-augmented sites on a per implant basis [6 studies].

Of the observational studies,

- Four studies[23, 44, 45, 53] found no significant difference in failure between those who had a bone graft and those who didn't
- One[17] found that the use of any reconstructive procedure significantly increased the risk of overall and inflammatory complication (HR = 1.18 & 1.17 respectively)

- Another[26] found a greater risk of failure when an alveolar distraction technique was used (HR = 7.1).

The 2 case series[31, 32] found that a bone graft procedure had no effect on outcome.

In their narrative review, Porter (2005)[39] states that the literature suggests that the osseointegration of dental implants can be affected by bone grafting and that if the reason for inadequate bone is due to periodontitis, infection or osteoporosis, it is possible that these conditions will affect the successful integration of the graft. They report that the success rate for implants placed in grafted bone has ranged from 77-85% compared to a success rate of 95% or more for implants placed in mature ungrafted bone.

The Academy of Osseointegration guideline (2008)[34] reported that maxillary sinus augmentation had been well documented and implants survival/success compares favourably to conventionally placed implants. Other bone augmentation techniques may not have as much evidence but the studies that met their inclusion criteria "were comparable and yielded favourable results supporting dental implants."

Discussion

Various bone grafting procedures and materials are used to ensure adequate bone quantity and quality for successful dental implant placement[34].

The previous review[1] concluded that it was likely that implants placed after maxillary sinus augmentation have a clinically significantly greater failure rate.

The newer evidence, however, is equivocal and when combined with the previous review's evidence weakens the conclusion that implants placed after maxillary sinus augmentation have a clinically significant risk of failure. The evidence for other augmentation techniques is too sparse to make any firm conclusion.

In addition, the success of implants placed in grafted bone will likely to be influenced by the magnitude of the graft, the type of implant material and the location of the implant. Other potential factors include the experience of the surgeon and the surgical technique chosen[1].

Suggested recommendation:
There is some weak evidence that implants placed after maxillary sinus augmentation may have an increased risk of failure.
There is no evidence that other bone graft/augmentation techniques alter significantly the risk of implant failure.

Table 8. Effect of bone graft/augmentation on dental implant failure.

Reference	LOE*	Description	Numbers		Key Results
			People	Implants	
Alvim-Pereira F, Montes C C, Thome G, Olandoski M & Trevilatto P C. 2008[45]	2-	Relationship between vitamin D receptor gene polymorphism & other clinical factors with dental implant failure.	217	1376	No significant difference in implant failures between those people who had a bone graft & those who didn't (p=0.433). Unadjusted OR = 0.83 (95%CI: 0.51-1.33)

Table 8. Effect of bone graft/augmentation on dental implant failure.					
Reference	**LOE***	**Description**	**Numbers**		**Key Results**
			People	**Implants**	
		NEODENT™ implants University setting			Not supported by Kaplan-Meier survival curve analysis.
Esposito M, Grusovin M G, Worthington H V & Coulthard P. 2008[3]	1+	Systematic review of effect of bone augmentation techniques on dental implant outcomes. (N=17 studies)			No significant difference in implant or prosthetic failure rates or major complication rates after bone augmentation compared to no augmentation (results from 2 studies only). OR = 5.00 (95%CI: 0.22-115.05) OR = 14.79 (95%CI: 0.76-289.43)
Gentile M A, Chuang S-K & Dodson T B. 2005[53]	2-	Survival of Bicon implants and risk factors associated with implant failure. Bicon 6x5.7mm dental implants. Hospital setting.	35	172	No increase in risk of implant failure with bone graft augmentation vs. none: HR = 2.6 995%CI: 0.6-12.1) p=0.23
Graziani F, Donos N, Needleman I, Gabriele M & Tonetti M. 2004[55]	1+	Systematic review of the effect of maxillary sinus floor augmentation on implant survival & complications in implants placed in the posterior maxilla. (N=5 studies)	394	>989	Patient-based survival (2 studies) ranged from 36-100% for augmented sites & 73-100% for non-augmented sites Implant-based survival (6 studies) ranged from 75-100% for both augmented and non-augmented sites One study reported no complications & the other reported 2 fistulae in the control group and 4 fistulae, 2 sinusitis, 1 dehiscence & 1 adverse load in the test group.
Kinsel R P & Liss M. 2007[31]	3	Effect of various factors on the survival of Straumann dental implants placed in edentulous arches. Private practice.	43	344	No statistically significant differences in failure rates between implants placed in grafted bone compared with native bone (p=0.415).
Lemmerman K J & Lemmerman N E. 2005[32]	3	Factors that affect the success or failure of dental implants. Various implant brands. Private periodontal clinic.	376	1003	Bony augmentation before or at implant placement had no statistical significant effect on outcome (no stats reported). Failure rates: 0-16.7%
McDermott N E, Chuang S-K, Woo V V & Dodson T B.	2+	Types and frequencies of complications associated with implants AND to	677	677	The use of a reconstructive procedure significantly increased the risk of any complication & also any inflammatory

Table 8. Effect of bone graft/augmentation on dental implant failure.					
Reference	**LOE***	**Description**	**Numbers**		**Key Results**
			People	**Implants**	
2003[17]		identify risk factors associated with implant complications. Bicon dental implants. Hospital Dentistry Centre.			complication: HR = 1.18 (95%CI: 1.03-1.34) p=0.017 [any] HR = 1.17 (95%CI: 1.001-1.36) p=0.049 [inflammatory]
McDermott N E, Chuang S-K, Woo V V & Dodson T B. 2006[44]	2+	Investigation of maxillary sinus augmentation (MSA) as an independent risk factor for implant failure using multivariate analysis. Bicon dental implants. Hospital Dentistry Centre.	677	2349	MSA does not significantly increase the risk of implant failure compared to no MSA: HR = 1.1 (95%CI: 0.6-1.9) p=0.9
Strietzel F P, Reichart P A, Kale A, Kulkarni M, Wegner B & Kuchler I. 2007[16]	2-	Systematic review of effect of smoking on implant survival (with or without sinus augmentation).	3383	16605	Significant difference in risk of implant failure in smokers who had augmentation compared with smokers who didn't have augmentation: OR=2.15 (95%CI: 1.86-2.49) [smokers without augmentation] (N=18 studies) OR=3.16 (95%CI: 2.26-5.77) [smokers with augmentation] (N=6 studies) p=0.039
Sverzut A T, Stabile G A V, de Moraes M, Mazzonetto R & Moreira R W F. 2008[26]	2-	Tobacco use as a risk failure for early implant failure. Implant brand not reported. University setting.	650	1628	Significantly greater risk of failure when alveolar distraction technique used: HR = 7.1740 p=0.0073
Woo V V, Chuang S-K, Daher S, Muftu A & Dodson T B. 2004[23]	2-	Assess the use of dentoalveolar reconstructive procedures as a risk factor for implant failure. Bicon dental implants. Hospital setting.	677	677	Dentoalveolar reconstructive procedures (DRP) were not a significant risk factor for implant failure: HR = 1.4 (95%CI: 0.7-2.9) p=0.32

**LOE = level of evidence*

Effect of osteoporosis

Seven papers[6-8, 11, 13, 24, 45] were reviewed that evaluated the effect of osteoporosis on implant survival/success, including six cohort and one case-control study (Table 9).

Of the cohort studies,

- Alsaadi (2007)[6] found that osteoporosis significantly increased the risk of early implant failure (OR = 2.88) whereas Alsaadi (2008a)[7] found that osteoporosis did not significantly increase the risk of late implant failure (OR = 2.73)
- Another study by Alsaadi (2008b)[8] reported that osteoporosis was not related to early implant failure however there were no failures in the group with osteoporosis
- A smaller cohort study[11] found that neither osteopaenia nor osteoporosis significantly increased the risk of failure (OR = 0.98 & 1.14 respectively)
- In the only case-control study[45], osteoporosis did not significantly change the odds of failure (unadjusted OR = 0.57 (95%CI: 0.05-5.53))
- In the last two cohort studies[13, 24] the presence of osteoporosis was recorded but no results specific to this disorder was reported.

Of the narrative reviews,

Wood (2004)[42] concluded that there is no evidence for systemic osteoporosis being a risk factor for implant failure but that "for patients with extreme osteoporosis, it may be wise to be cautious with maxillary implant treatment".

Hwang (2007)[56] concluded that osteoporosis alone does not affect implant success

Zitzmann (2008)[43] lists osteoporosis as a condition that increases the risk of implant failure and suggests consideration of calcium substitution, a longer healing period and avoidance of high torque for abutment screw fixation.

Porter (2005)[39] found few published clinical studies on the topic with conflicting opinions and concluded that visual assessment of bone density at placement[42] may be more pertinent to implant success.

Scully (2007)[57] in their review found similar success rates in people with osteoporosis compared to those without but adds that sinus lifts may be contraindicated.

Discussion

Osteoporosis may theoretically affect osseointegration[42] because bone metabolism is impaired. However, the conclusion in the previous ACC review[1] was that the evidence did not support the idea that osteoporosis was strongly associated with implant loss.

Of the primary studies reviewed above, only one found an elevated risk of implant failure in people with osteoporosis. The rest of the studies had problems with their methodology and were considered to be at high risk of bias, confounding or chance findings. Moreover, the narrative reviews' conclusions were often based on very few studies, studies that were included in the previous ACC dental implant review[1] and they often cited the same studies. This introduces bias by making the body of evidence appear stronger than it actually is.

Suggested recommendation:
There is insufficient evidence that osteoporosis is a relevant risk factor for implant failure.

Table 9. Effect of osteoporosis on dental implant failure.

Reference	LOE*	Description	Numbers		Key Results
			People	Implants	
Alsaadi G, Quirynen M, Komarek A & van Steenberghe D. 2007[6]	2+	Dental implant (Brånemark system®) survival and factors related to risk of early* failure. University setting. *early = before or up to abutment connection	2004	6946	Osteoporosis significantly increased the risk of early implant failure: OR = 2.88 (95%CI: 1.15-5.48)
Alsaadi G, Quirynen M, Komarek A & van Steenberghe D. 2008a[7]	2-	Dental implant (Brånemark system®) survival and factors related to risk of late* failure. University setting. *late = after occlusal loading is established	412	1514	Osteoporosis was not related to late failure: OR = 2.73 (95%CI: 0.79-9.39) p=0.11
Alsaadi G, Quirynen M, Michiles K, Teughels W, Komarek A & van Steenberghe D. 2008b[8]	2-	Dental implant (MkII TiUnite™) survival and factors related to early* failure. University setting. *early = before or up to abutment connection	238	720	Reported that osteoporosis was not related to implant early failure: 0% (osteoporosis) vs. 2.03% (no osteoporosis) p=1
Alvim-Pereira F, Montes C C, Thome G, Olandoski M & Trevilatto P C. 2008[45]	2-	Relationship between vitamin D receptor gene polymorphism & other clinical factors with dental implant failure. NEODENT™ implants University setting.	217	1376	2.2% of people in 'no failure' group had osteoporosis compared to 1.3% of people in 'at least 1 failure' group [p=1] Unadjusted OR = 0.57 (95%CI: 0.058-5.53)
Holahan C M, Koka S, Kennel K A, Weaver A L, Assad D A, Regennitter F J & Kademani D. 2008[11]	2-	Effect of a diagnosis of osteoporosis or osteopenia in women 50yrs or over on the survival rate of osseointegrated dental implants. University setting.	192	646	No significant effect on implant survival in women: HR[osteopenia] = 0.98 (95%CI: 0.50-2.60) p=0.76 HR[osteoporosis] = 1.14 (95%CI: 0.40-2.42) p=0.97

Table 9. Effect of osteoporosis on dental implant failure.					
Reference	**LOE***	**Description**	**Numbers**		**Key Results**
			People	**Implants**	
Mundt T, Mack F, Schwahn C & Biffar R. 2006[13]	2-	Potential risk factors for implant failure. Tiolox dental implants. Private practice.	159	663	"Diseases" reported as having no effect on implant failure
Roos-Jansaker A M, Lindahl C, Renvert H & Renvert S. 2006[24]	2-	Investigate the long-term outcome of implant therapy and association between various factors and implant loss. Brånemark® dental implants Public Dental Health Service.	218	1057	No results reported for osteoporosis group

**LOE = level of evidence*

Effect of hormone replacement therapy (HRT), radical hysterectomy &/or menopausal status

Three cohort[8, 20, 21] and one case-control study[45] were reviewed that evaluated the effect of HRT, radical hysterectomy &/or menopausal status on implant survival/success (Table 10).

- Post-menopausal HRT was predictive of the number of failed implants per person in one study[21] (p=0.001) and women 50 years or older taking HRT had a greater failure rate than those not taking HRT (9.52% vs. 1.63%; p<0.001)[8]. This same study[8] found that implant survival was approximately 7.8% less in women who had had a radical hysterectomy (p=0.04)

- A smaller study[20] found no relationship between HRT or menopausal status and implant failure and nor did another case-control study[45]

- The case-control study[45] found no significant difference in percentage of people taking HRT between the 'at least one failure' group and the 'no failure' group (21.3% vs. 21.2% respectively; p=1).

Authors of the identified narrative reviews[39, 42, 56] disagree on the impact and the tendency of postmenopausal women to have dental implants that fail. There is some consensus[39, 42, 56] however that menopausal status is a concern in the maxilla only.

Discussion

Osteoporosis occurs often in postmenopausal women[42] and this has raised concerns that oestrogen status may affect osseointegration of dental implants.

The previous review[1] concluded that postmenopausal status is probably not an important risk factor for implant loss and that HRT may not be of benefit i.e. improve failure rate.

The new evidence identified is conflicting – one study reported that women who have had a radical hysterectomy or who were at least 50 years old and taking HRT had a 8-9% greater failure rate; the other reported that taking HRT was predictive of the number of failed implants per person; the other two found no significant association between taking HRT or menopausal status and implant failure.

On balance, there is a suggestion that these factors may affect implant failure but probably not to an extent that is clinically relevant; however they will be important to be considered in the context of other risk factors. It is likely that these variables are confounded by and confound other factors like bone quality, bone quantity and osteoporosis.

Suggested evidence statement:
There is insufficient evidence to show that HRT, radical hysterectomy or menopausal status are important risk factors for implant failure.

Table 10. Effect of HRT, radical hysterectomy & menopausal status on dental implant failure.

Reference	LOE*	Description	Numbers		Key Results
			People	Implants	
Alsaadi G, Quirynen M, Michiles K, Teughels W, Komarek A & van Steenberghe D. 2008b[8]	2-	Dental implant (MkII TiUnite™) survival and factors related to early* failure. University setting. *early = before or up to abutment connection	238	720	Survival was greater in women who had not had a radical hysterectomy (98.74%) compared with women who had had a radical hysterectomy (90.91%) [p=0.04] Women who were at least 50 yrs old and taking HRT had a greater failure rate (9.52%) than women at least 50 yrs old not taking HRT (1.63%) when clustering was taken into account [p=0.06 Fisher; p<0.001 GEE].
Alvim-Pereira F, Montes C C, Thome G, Olandoski M & Trevilatto P C. 2008[45]	2-	Relationship between vitamin D receptor gene polymorphism & other clinical factors with dental implant failure. NEODENT™ implants University setting.	217	1376	21.2% of people in 'no failure' were taking HRT* compared to 21.3% of people in 'at least 1 failure' group [p=1] Unadjusted OR=1.01 (95%CI: 0.51-1.97) * reported as "hormony reposition" in the paper
Moheng P & Feryn J-M. 2005[20]	2-	Biomarkers of bone turnover as predictors of implant failure and other factors that may be related to failure. Frialit-2® or IMZ® Twin Plus dental implants. Hospital Dental Implantology Centre.	93	266	Menopausal status & HRT was not related to implant failure (p=0.70).
Moy P K, Medina D, Shetty V & Aghaloo	2-	Risk factors for implant failure.	1140	4680	Post-menopausal HRT was predictive of the number of failed implants per patient

Table 10. Effect of HRT, radical hysterectomy & menopausal status on dental implant failure.					
Reference	LOE*	Description	Numbers		Key Results
			People	Implants	
T L. 2005[21]		Various dental implant brands. University setting.			(p=0.001) on multiple linear regression.

**LOE = level of evidence*

Effect of age

Fourteen papers were reviewed that evaluated the effect of age on implant survival/success, including 12 cohort studies and 2 case series (Table 11).

Of the cohort studies:

- Eleven [9, 17-21, 26, 44, 51-53] found no association between implant failure and age
- And one[22] found an increased risk of early failure in those people ≤60yrs compared to those people >60yrs (OR = 4.53).

Of the 2 case series:

- One[31] found no significant differences in failure rates between people ≤59yrs & ≥60yrs old
- And the other[29] found no correlation between age and implant failure but no statistics were reported.

Porter (2005)[39] stated that the impact of age is unclear but that older people may need longer periods of healing after a procedure. They do, however list "patient more than 60 years old" in their table as a negative factor for implant success.

Two narrative reviews[42, 43] conclude that increasing chronological age ***per se*** is not a contraindication for implant placement but that, especially in the older person, it would depend on how they would tolerate the procedure[43], the presence of relevant comorbidities, their ability to maintain oral hygiene, and potential increased healing times[42]. It is likely that available bone quantity and quality are more important than age[42].

In young adults, Zitzmann (2008)[43] recommends that for a single anterior tooth replacement, implant placement should be delayed until after the age of 25 years. Moreover, Wood (2004)[42] agrees that most authors recommend that implant placement should be postponed until jaw growth has finished, how to assess when this has occurred is not clearly established.

Discussion

The evidence is consistent in that older age is not a significant risk factor on its own for implant failure. There also appears to be a consensus opinion that implants should only be placed after jaw bone growth has finished.

Suggested evidence statement:
Older age, as a single risk factor, is not a contraindication for implant placement.
Implant placement should be delayed in young people until growth is complete

Table 11. Effect of age on dental implant failure.

Reference	LOE*	Description	Numbers		Key Results
			People	Implants	
Anitua E, Orive G, Aguirre J J, Ardanza B & Andia I. 2008[9]	2-	Dental implant (BTI®)* survival and factors related to failure. *Biotechnology Institute	1060	5787	No significant association between age and implant failure.
DeLuca S, Habsha E & Zarb G A. 2006[19]	2+	Survival of Brånemark implants in relation to smoking. Brånemark implants. University setting.	464	1852	No significant association between age and implant failure.
Elkhoury J S, McGlumphy E A, Tatakis D N & Beck F M. 2005[52]	2-	Clinical parameters associated with long-term (5yr) success or failure of single tooth implants.	39	39	No significant association between age and implant failure (p=0.1287).
Gentile M A, Chuang S-K & Dodson T B. 2005[53]	2-	Survival of Bicon implants and risk factors associated with implant failure. Bicon 6x5.7mm dental implants. Hospital setting.	35	172	No significant association between age at implant placement and implant failure. HR = 1.0 (95%CI: 0.9-1.0) p=0.14
Herrmann I, Lekholm U, Holm S & Kultje C. 2005[51]	2-	Influence of some patient & implant characteristics on implant survival.	487	487	No significant association between age and implant failure.
Kinsel R P & Liss M. 2007[31]	3	Effect of various factors on the survival of Straumann dental implants placed in edentulous arches. Private practice.	43	344	No significant differences in failure rates between people ≤59yrs & ≥60yrs old (p=0.721).
Kourtis S G, Sotiriadou S, Voliotis S & Challas A. 2004[29]	3	Associate the causes of dental implant failure with some potential risk factors. Various implant brands. Private dental clinics (4)	405	1692	No correlation between age and implant failure (no stats reported).
McDermott N E,	2+	Types and frequencies of	677	677	No association between age and overall*

Table 11. Effect of age on dental implant failure.					
Reference	**LOE***	**Description**	**Numbers**		**Key Results**
			People	**Implants**	
Chuang S-K, Woo V V & Dodson T B. 2003[17]		complications associated with implants AND to identify risk factors associated with implant complications. Bicon dental implants. Hospital Dentistry Centre.			or inflammatory† complications. *HR [older vs. younger] = 1.0041 (95%CI: 0.98-1.01) p=0.89 multivariate analysis †HR = 1.00 (95%CI: 0.98-1.02) p=0.88 bivariate analysis
McDermott N E, Chuang S-K, Woo V V & Dodson T B. 2006[44]	2+	Investigation of maxillary sinus augmentation as an independent risk factor for implant failure using multivariate analysis. Bicon dental implants. Hospital Dentistry Centre.	677	2349	No association between age and implant failure. HR = 1.02 (95%CI: 0.99-1.05) p=0.22
Moheng P & Feryn J-M. 2005[20]	2-	Biomarkers of bone turnover as predictors of implant failure and other factors that may be related to failure. Frialit-2® or IMZ® Twin Plus dental implants. Hospital Dental Implantology Centre.	93	266	No association between age and implant failures (p=0.79)
Moy P K, Medina D, Shetty V & Aghaloo T L. 2005[21]	2-	Risk factors for implant failure. Various dental implant brands. University setting.	1140	4680	Increased risk of failure in the 60-79yr age group compared to those <40yrs on univariate analysis* but not on multivariate analysis. *RR =2.24 (95%CI: 1.28-3.93)
Noguerol B, Munoz R, Mesa F, de Dios Luna J & O'Valle F. 2006[22]	2-	Determine accuracy of Periotest® to monitor primary implant stability and identify variables associated with **early** implant failure. Brånemark® dental implants. Single periodontal clinic	316	1084	Increased risk of early failure in those people ≤60yrs compared to those people >60yrs: OR = 4.53 (95%CI: 1.34-15.27)
Susarla S M, Chuang S-K & Dodson T B. 2008[18]	2+	Risk factors for implant failure. Bicon dental implants.	855	2826	Age was not a significant risk factor for implant failure: HR = 1.00 (95%CI: 0.98-1.0) p=0.57

Table 11. Effect of age on dental implant failure.					
Reference	**LOE***	**Description**	**Numbers**		**Key Results**
			People	**Implants**	
		Private practice.			
Sverzut A T, Stabile G A V, de Moraes M, Mazzonetto R & Moreira R W F. 2008[26]	2-	Tobacco use as a risk failure for early implant failure. Implant brand not reported. University setting.	650	1628	No significant difference in risk of implant failure with respect to age: HR = 1.0750 p=0.7358

**LOE = level of evidence*

Effect of radiotherapy

Four cohort studies[6-8, 21] and 4 narrative reviews were reviewed that evaluated the effect of radiotherapy on implant survival/success (Table 12).

- Alsaadi (2007)[6] and Alsaadi (2008b)[8] found that radiotherapy of the concerned area did not increase the risk of early implant failure
- Alsaadi (2008a)[7], on the other hand, found that radiotherapy increased the risk of late implant failure (OR = 3.32 (95%CI: 1.49-7.35)) although this was only based on 2 people with 6 implants
- Moy (2005)[21] also found that people who had a history of head & neck radiotherapy had a significantly increased risk of failure (RR = 1.87).

Of the narrative reviews, Scully et al (2007)[57] and Porter & von Fraunhofer (2005)[39] list radiotherapy as causing a reduced success rate of implants as does Zitzmann et al (2008)[43]. Moreover, Porter & von Fraunhofer (2005)[39] and Wood & Vermilyea (2004)[42] both conclude that radiotherapy should not be an absolute contraindication, especially in the mandible.

Discussion

The concerns about radiotherapy arise from its effects on salivary production, blood supply to bone and soft tissues and the risk of osteoradionecrosis[42]. The evidence above suggests that a history of radiotherapy to the area where an implant is to be placed may be a risk factor for late implant failure and this is iterated in the narrative review literature.

When considered with the evidence in the last ACC review[1], it is unlikely that the recommendation in the Dental Implant Guideline should be changed.

Suggested evidence statement:
There is some evidence that implant failure rates in the maxilla are usually significantly increased in people who have previously had irradiation of the jaw, regardless of the total

radiation dose.

Table 12. Effect of radiotherapy on dental implant failure.

Reference	LOE*	Description	Numbers		Key Results
			People	Implants	
Alsaadi G, Quirynen M, Komarek A & van Steenberghe D. 2007[6]	2+	Dental implant (Brånemark system®) survival and factors related to risk of early* failure. University setting. *early = before or up to abutment connection	2004	6946	Radiotherapy did not increase the risk of early implant failure. OR = 0.36 (95%CI: 0.028-4.65).
Alsaadi G, Quirynen M, Komarek A & van Steenberghe D. 2008a[7]	2-	Dental implant (Brånemark system®) survival and factors related to risk of late* failure. University setting. *late = after occlusal loading is established	412	1514	Radiotherapy increased the risk of late implant failure. OR = 3.32 (95%CI: 1.49-7.35) p=0.003
Alsaadi G, Quirynen M, Michiles K, Teughels W, Komarek A & van Steenberghe D. 2008b[8]	2-	Dental implant (MkII TiUnite™) survival and factors related to early* failure. University setting. *early = before or up to abutment connection	238	720	Radiotherapy to the concerned area did not lead to an increased incidence of early implant failures. p<0.05
Moy P K, Medina D, Shetty V & Aghaloo T L. 2005[21]	2-	Risk factors for implant failure. Various dental implant brands. University setting.	1140	4680	People who had a history of head & neck radiotherapy had a significantly increased risk of failure. RR = 1.87 p=0.05

**LOE = level of evidence*

Effect of chemotherapy

Four cohort studies and 3 narrative reviews were identified that evaluated the effect of chemotherapy on implant survival/success (Table 13).

- Three studies[6-8] could not evaluate the effect of a history of chemotherapy on implant success/survival due to the fact that no failures occurred in these groups. The other study[21], found that having a history of chemotherapy had no effect on the risk of failure (RR = 0.63).

In their narrative review, Wood et al (2004)[42] state that implant placement during active chemotherapy cannot be supported by available data but that there are a few case reports of successful implant placement in people who have a history of chemotherapy. This is supported by Zitzmann et al (2008)[43] who list chemotherapy as an absolute but temporary contraindication.

Scully (2007)[57], in their review, conclude that there is little evidence that cancer chemotherapy influences the success of implants. This appears to be based on only one study (which is also cited in Wood et al (2004)[42]).

Discussion

The evidence is very limited, however it seems there is a consensus that dental implants should not be placed in people undergoing active chemotherapy.

There is no evidence, based on one study and expert opinion, that people who have had chemotherapy in the past have an elevated risk of implant failure.

Suggested evidence statement:
There is a consensus opinion that dental implants should not be placed in people undergoing active chemotherapy.

Table 13. Effect of chemotherapy on dental implant failure.

Reference	LOE*	Description	Numbers		Key Results
			People	Implants	
Alsaadi G, Quirynen M, Komarek A & van Steenberghe D. 2007[6]	2+	Dental implant (Brånemark system®) survival and factors related to risk of early* failure. University setting. *early = before or up to abutment connection	2004	6946	Unable to evaluate as no failures in this group.
Alsaadi G, Quirynen M, Komarek A & van Steenberghe D. 2008a[7]	2-	Dental implant (Brånemark system®) survival and factors related to risk of late* failure. University setting. *late = after occlusal loading is established	412	1514	Unable to evaluate as no failures in this group.
Alsaadi G, Quirynen M, Michiles K, Teughels W, Komarek A & van Steenberghe D. 2008b[8]	2-	Dental implant (MkII TiUnite™) survival and factors related to early* failure. University setting. *early = before or up to abutment connection	238	720	Unable to evaluate as no failures in this group.

Table 13. Effect of chemotherapy on dental implant failure.					
Reference	**LOE***	**Description**	**Numbers**		**Key Results**
			People	**Implants**	
Moy P K, Medina D, Shetty V & Aghaloo T L. 2005[21]	2-	Risk factors for implant failure. Various dental implant brands. University setting.	1140	4680	No effect on risk of failure. RR = 0.63 (95%CI: 0.08-5.02)

**LOE = level of evidence*

Effect of coagulation problems

Four cohort studies and 2 narrative reviews were identified that evaluated the effect of coagulation problems on implant survival/success (Table 14).

- Three of the cohort studies[6-8] found no significant change in risk of failure in people with coagulation disorders and the other[13] also reported that "diseases", which included coagulation disorders, had no effect on implant failure.

Both narrative reviews[43, 57] recommend that even though there appears to be no evidence that coagulation disorders are contraindicated, these people may not be a good risk group and medical advice should be taken first. This will probably apply to people taking anticoagulant medication[58] as well.

Discussion

There is limited evidence from a few studies that coagulation disorders do not increase the risk of implant failure, but there is a consensus that medical advice should be taken before deciding to proceed with implant treatment.

Suggested recommendation:
Medical advice should be sought for people with coagulation disorders or taking anticoagulant medication before proceeding with implant placement.

Table 14. Effect of coagulation problems on dental implant failure.					
Reference	**LOE***	**Description**	**Numbers**		**Key Results**
			People	**Implants**	
Alsaadi G, Quirynen M, Komarek A & van Steenberghe D. 2007[6]	2+	Dental implant (Brånemark system®) survival and factors related to risk of early* failure. University setting. *early = before or up to abutment connection	2004	6946	No effect on early implant failure: OR = 2.00 (95%CI: 0.93-4.28) p=0.08

Table 14. Effect of coagulation problems on dental implant failure.					
Reference	**LOE***	**Description**	**Numbers**		**Key Results**
			People	**Implants**	
Alsaadi G, Quirynen M, Komarek A & van Steenberghe D. 2008a[7]	2-	Dental implant (Brånemark system®) survival and factors related to risk of late* failure. University setting. *late = after occlusal loading is established	412	1514	No effect on late implant failure: OR = 0.29 (95%CI: 0.047-1.75) p=0.18
Alsaadi G, Quirynen M, Michiles K, Teughels W, Komarek A & van Steenberghe D. 2008b[8]	2-	Dental implant (MkII TiUnite™) survival and factors related to early* failure. University setting. *early = before or up to abutment connection	238	720	No significant difference in implant failure (1.82% with no coagulation problem compared with 3.39% with a coagulation problem): p=0.32; 0.42
Mundt T, Mack F, Schwahn C & Biffar R. 2006[13]	2-	Potential risk factors for implant failure. Tiolox dental implants. Private practice.	159	663	"Diseases" reported as having no effect on implant failure

**LOE = level of evidence*

Effect of edentulousness/proximity to natural teeth

Six papers were reviewed that evaluated the effect of edentulousness or proximity to natural teeth on implant survival/success, including four cohort, one case-control and one case series (Table 15).

- Of the cohort studies, one[6] found that the risk of early failure was 2.77 times higher in implants neighbouring teeth than in implants placed in fully edentulous mouths. This increased to 4.8 times when compared to implants in the presence of teeth in the antagonistic jaw only. Even though these results reach statistical significance, the data was available for only one third of the study population & the summary estimates were not adjusted for potential confounders i.e. high risk of bias and confounding

- Another study[8] which found higher early failure rates in implants neighbouring natural teeth compared to those in fully edentulous mouths (p=0.004). Of note, there were no failures of implants placed in a jaw having teeth (but not neighbouring the implant) or of implants placed in an edentulous jaw opposing a jaw with teeth

- McDermott (2006)[44] found that the dental implant's proximity to natural teeth was not significantly associated with implant failure on multivariate analysis

- Degree of edentulousness was not related to late implant failure in another study[7]

- The case-control study[45] found that there were more totally edentulous participants in the group with no implant failures compared to the group with at least one failure (19% vs. 6.3%; p=0.009)
- The single case series[29] found that there was a significant difference in the failure rates of implants replacing a single tooth, implants placed in partially edentulous people or implants placed in fully edentulous people (7%, 56%, 37% respectively).

Discussion

The evidence for the effect of the type of edentulousness and proximity to natural dentition is inconclusive and conflicting. In addition, there are considerable concerns regarding the internal validity of the studies, and it is unclear whether these variables are primary risk factors or proxies for other risk factors e.g. reason for tooth loss, occlusal forces. Moreover, the utility of these variables as patient selection factors for the ACC population is debatable.

Suggested evidence statement:
There is insufficient evidence that the types of edentulousness or proximity to natural dentition are significant risk factors for implant failure.

Table 15. Effect of edentulousness/proximity to natural teeth on dental implant failure.

Reference	LOE*	Description	Numbers		Key Results
			People	Implants	
Alsaadi G, Quirynen M, Komarek A & van Steenberghe D. 2007[6]	2+	Dental implant (Brånemark system®) survival and factors related to risk of early* failure. University setting. *early = before or up to abutment connection	2004	6946	On univariate analysis: OR [implants neighbouring teeth vs. implants in full edentulism] = 2.77 (1.45-5.28) OR [implants in presence of teeth in same jaw vs. implants in full edentulism] = 1.97 (0.94-4.11) OR [implants in presence of teeth in antagonistic jaw only vs. implants in full edentulism] = 0.57 (0.17-1.93) OR [implants neighbouring teeth vs. implants in the presence of teeth in antagonistic jaw only] = 4.879 (1.59-15.11) p<0.001
Alsaadi G, Quirynen M, Komarek A & van Steenberghe D. 2008a[7]	2-	Dental implant (Brånemark system®) survival and factors related to risk of late* failure. University setting. *late = after occlusal loading is established	412	1514	Not related to late failure (p=0.85).

Table 15. Effect of edentulousness/proximity to natural teeth on dental implant failure.					
Reference	**LOE***	**Description**	**Numbers**		**Key Results**
			People	**Implants**	
Alsaadi G, Quirynen M, Michiles K, Teughels W, Komarek A & van Steenberghe D. 2008b[8]	2-	Dental implant (MkII TiUnite™) survival and factors related to early* failure. University setting. *early = before or up to abutment connection	238	720	Higher early failure rates in implants neighbouring natural teeth (p=0.004).
Alvim-Pereira F, Montes C C, Thome G, Olandoski M & Trevilatto P C. 2008[45]	2-	Relationship between vitamin D receptor gene polymorphism & other clinical factors with dental implant failure. NEODENT™ implants University setting.	217	1376	More edentulous participants in 'no implant loss' group (19.0%) compared to 'at least 1 implant failure' group (6.3%). p=0.009 Unadjusted OR = 0.28 (95%CI: 0.18-0.91)
Kourtis S G, Sotiriadou S, Voliotis S & Challas A. 2004[29]	3	Report the survival of dental implants and associate the causes of failure with some potential risk factors. Variety of implant brands. Private practices (4).	405	1692	Significantly less failure rate for implants replacing a single tooth (7%) compared to failure rates in totally or partially edentulous participants (37% & 56% respectively).
McDermott N E, Chuang S-K, Woo V V & Dodson T B. 2006[44]	2+	Investigation of maxillary sinus augmentation as an independent risk factor for implant failure using multivariate analysis. Bicon dental implants. Hospital Dentistry Centre.	677	2349	Proximity to natural teeth – not significant on multivariate analysis

**LOE = level of evidence*

Effect of gastric disease

Three cohort studies were reviewed that evaluated the effect of gastric disease on implant survival/success (Table 16).

- Two of these studies[6, 7] found that the presence of a 'gastric problem' did not increase the risk of early[6] or late[7] implant failure. Of note, Crohn's disease was analysed separately.
- The other study[8] found that the survival of dental implants was significantly less in people with a gastric disease (92.86% vs. 98.38%; p=0.04/0.01).

Discussion

There are some concerns about the validity of these results: three studies[6, 7, 8] are probably under-powered. In addition, the definition of 'gastric problem' in these studies is vague and probably includes many quite distinct conditions.

Suggested evidence statement:
There is insufficient evidence that people with 'gastric problems' have a greater risk of implant failure.

Table 16. Effect of gastric disease on dental implant failure.

Reference	LOE*	Description	Numbers		Key Results
			People	Implants	
Alsaadi G, Quirynen M, Komarek A & van Steenberghe D. 2007[6]	2+	Dental implant (Brånemark system®) survival and factors related to risk of early* failure. University setting. *early = before or up to abutment connection	2004	6946	The presence of 'gastric problems' did not significantly increase the risk of early implant failure: OR = 1.81 (95%CI: 0.55-5.97) p=0.33
Alsaadi G, Quirynen M, Komarek A & van Steenberghe D. 2008a[7]	2-	Dental implant (Brånemark system®) survival and factors related to risk of late* failure. University setting. *late = after occlusal loading is established	412	1514	The presence of a 'gastric problem' had no significant effect on the risk of late implant failures: OR = 0.99 (95%CI: 0.24-4.01) p=0.98
Alsaadi G, Quirynen M, Michiles K, Teughels W, Komarek A & van Steenberghe D. 2008b[8]	2-	Dental implant (MkII TiUnite™) survival and factors related to early* failure. University setting. *early = before or up to abutment connection	238	720	Survival rate in people with a gastric problem (92.86%) was significantly less than the survival rate in people without a gastric problem (98.38%). p=0.04 Fisher; 0.01 GEE

**LOE = level of evidence*

Effect of Crohn's disease

Only three studies[6-8] and one narrative review[57] were located that evaluated the effect of Crohn's disease on implant survival/success (Table 17).

- One cohort study[6] found that the presence of Crohn's disease significantly increased the risk of early implant failure (OR = 7.95). Another, smaller study[8] found that, after correcting for clustering, the survival rate of implants was

significantly less in people with Crohn's disease (p=0.02 when clustering is taken into account)

- The remaining study[7] found that Crohn's disease had no significant effect on the risk of late implant failure.

The narrative review[57] stated that people with Crohn's disease on systemic medication may show delayed and altered wound healing and recommended that surgery must be closely monitored.

Discussion

There is limited evidence from two studies that Crohn's disease may increase the risk of early implant failure. However there are serious limitations to the studies including the small numbers of people with Crohn's disease included in the study e.g. 12 in Alsaadi (2008b)[8] and only one of those people had an implant failure. The numbers of people in Alsaadi (2007)[6] with Crohn's disease was not reported. It is also not clear whether the potential confounding effects from neither medications like corticosteroids or immunosuppressants nor the severity of the disease are controlled for.

Suggested evidence statement:
There is insufficient evidence that the presence of Crohn's disease is a significant risk factor for implant failure.

Table 17. Effect of Crohn's disease on dental implant failure.

Reference	LOE*	Description	Numbers		Key Results
			People	Implants	
Alsaadi G, Quirynen M, Komarek A & van Steenberghe D. 2007[6]	2+	Dental implant (Brånemark system®) survival and factors related to risk of early* failure. University setting. *early = before or up to abutment connection	2004	6946	The presence of Crohn's disease significantly increased the risk of early implant failure: OR = 7.95 (95%CI: 3.47-18.24)
Alsaadi G, Quirynen M, Komarek A & van Steenberghe D. 2008a[7]	2-	Dental implant (Brånemark system®) survival and factors related to risk of late* failure. University setting. *late = after occlusal loading is established	412	1514	The presence of Crohn's disease did not have a significant effect on the risk of late implant failures: OR = 10.09 (95%CI: 0.73-139.79) p=0.009
Alsaadi G, Quirynen M, Michiles K, Teughels W, Komarek A & van Steenberghe D. 2008b[8]	2-	Dental implant (MkII TiUnite™) survival and factors related to early* failure. University setting. *early = before or up to	238	720	Survival rate in people with Crohn's disease (91.67%) was less than the survival rate in people without Crohn's disease (98.16%). Depending on the method used: p=0.21 Fisher; 0.02 GEE†

Table 17. Effect of Crohn's disease on dental implant failure.					
Reference	LOE*	Description	Numbers		Key Results
			People	Implants	
		abutment connection			†Generalising estimating equation – used to correct for clustering

**LOE = level of evidence*

Effect of cardiac disease

Nine papers[6-8, 13, 21, 24, 45, 56, 57] were reviewed that evaluated the effect of cardiac disease on implant survival/success, including 7 cohort, one case-control study and 2 narrative reviews (Table 18).

- All of the studies[6-8, 13, 21, 24, 45] reported that cardiac disease had no significant effect on implant failure, including two[13, 24] that did not report any results for this group

The two narrative reviews[56, 57] reported that although cardiovascular disease does not appear to affect implant survival or success[56], people with such conditions may not be a good risk group and medical advice should be taken first[57].

Discussion

Cardiac disease or cardiovascular disease may theoretically affect blood supply to the implant site and hence reduce survival or success. The evidence identified here has some limitations with regard to sample size and potential confounding factors e.g. severity of disease, but gives no suggestion that cardiovascular disease has role in implant failure.

Suggested evidence statement:
There is insufficient evidence that the presence of cardiovascular disease significantly increases the risk of implant failure.

Table 18. Effect of cardiac disease on dental implant failure.					
Reference	LOE*	Description	Numbers		Key Results
			People	Implants	
Alsaadi G, Quirynen M, Komarek A & van Steenberghe D. 2007[6]	2+	Dental implant (Brånemark system®) survival and factors related to risk of early* failure. University setting. *early = before or up to abutment connection	2004	6946	No significant effect on risk of early implant failure: OR = 0.42 (95%CI: 0.15-1.22)
Alsaadi G, Quirynen M, Komarek A & van Steenberghe D. 2008a[7]	2-	Dental implant (Brånemark system®) survival and factors related to risk of late* failure.	412	1514	No significant effect on risk of late implant failure: OR = 2.09 (95%CI: 0.65-6.73) p=0.23

Table 18. Effect of cardiac disease on dental implant failure.					
Reference	**LOE***	**Description**	**Numbers**		**Key Results**
			People	**Implants**	
		University setting. *late = after occlusal loading is established			
Alsaadi G, Quirynen M, Michiles K, Teughels W, Komarek A & van Steenberghe D. 2008b[8]	2-	Dental implant (MkII TiUnite™) survival and factors related to early* failure. University setting. *early = before or up to abutment connection	238	720	No significant difference in early failure rates in participants with a cardiovascular disease (2.15%) compared to those without (0%) p=0.38 Fisher
Alvim-Pereira F, Montes C C, Thome G, Olandoski M & Trevilatto P C. 2008[45]	2-	Relationship between vitamin D receptor gene polymorphism & other clinical factors with dental implant failure. NEODENT™ implants University setting	217	1376	6.6% of 'no failure' group had cardiovascular disease compared to 10.0% in 'failure' group (p=0.434). Unadjusted OR = 0.69 (95%CI: 0.36-1.32)
Moy P K, Medina D, Shetty V & Aghaloo T L. 2005[21]	2-	Risk factors for implant failure. Various dental implant brands. University setting.	1140	4680	No significant difference on univariate analysis: RR = 1.02 (95%CI: 0.58-1.78)
Mundt T, Mack F, Schwahn C & Biffar R. 2006[13]	2-	Potential risk factors for implant failure. Tiolox dental implants. Private practice.	159	663	"Diseases" reported as having no effect on implant failure
Roos-Jansaker A M, Lindahl C, Renvert H & Renvert S. 2006[24]	2-	Investigate the long-term outcome of implant therapy and association between various factors and implant loss. Brånemark® dental implants Public Dental Health Service.	218	1057	No results reported for people with coronary heart disease.

**LOE = level of evidence*

Effect of hypercholesterolaemia

Three cohort studies[6-8] were reviewed that evaluated the effect of hypercholesterolaemia on implant survival/success (Table 19).

- Two of the studies[6, 7] found that hypercholesterolaemia did not affect the risk of either early[6] or late[7] implant failure. The other[8] found that hypercholesterolaemia "did not lead to an increase in failure", however there were no implant failures in this group.

Discussion

There is no evidence that hypercholesterolaemia plays a role in implant failure.

Suggested evidence statement:
There is insufficient evidence that hypercholesterolaemia is a significant risk factor for implant failure.

Table 19. Effect of hypercholesterolaemia on dental implant failure.

Reference	LOE*	Description	Numbers		Key Results
			People	Implants	
Alsaadi G, Quirynen M, Komarek A & van Steenberghe D. 2007[6]	2+	Dental implant (Brånemark system®) survival and factors related to risk of early* failure. University setting. *early = before or up to abutment connection	2004	6946	No effect of hypercholesterolaemia on early implant failure: OR = 1.02 (95%CI: 0.31-3.35)
Alsaadi G, Quirynen M, Komarek A & van Steenberghe D. 2008a[7]	2-	Dental implant (Brånemark system®) survival and factors related to risk of late* failure. University setting. *late = after occlusal loading is established	412	1514	No effect of hypercholesterolaemia on late implant failure: OR = 1.19 (95%CI: 0.37-3.83); p=0.77
Alsaadi G, Quirynen M, Michiles K, Teughels W, Komarek A & van Steenberghe D. 2008b[8]	2-	Dental implant (MkII TiUnite™) survival and factors related to early* failure. University setting. *early = before or up to abutment connection	238	720	Hypercholesterolaemia "did not lead to an increase in failure." NB no failures in the hypercholesterolaemia group

**LOE = level of evidence*

Effect of hypertension

Four cohort studies[6-8, 21] and one case-control study[45] evaluated the effect of hypertension on implant failure (Table 20).

- All of the studies found that hypertension had no effect on the risk of implant failure.

Discussion

There is a lack of evidence that hypertension increases the risk of implant failure.

Suggested evidence statement:
There is insufficient evidence that hypertension is a significant risk factor for implant failure.

Table 20. Effect of hypertension on dental implant failure.

Reference	LOE*	Description	Numbers		Key Results
			People	Implants	
Alsaadi G, Quirynen M, Komarek A & van Steenberghe D. 2007[6]	2+	Dental implant (Brånemark system®) survival and factors related to risk of early* failure. University setting. *early = before or up to abutment connection	2004	6946	No effect of hypertension on early implant failure: OR = 0.97 (95%CI: 0.56-1.67)
Alsaadi G, Quirynen M, Komarek A & van Steenberghe D. 2008a[7]	2-	Dental implant (Brånemark system®) survival and factors related to risk of late* failure. University setting. *late = after occlusal loading is established	412	1514	No effect of hypertension on late implant failure: OR = 0.85 (95%CI: 0.29-2.43); p=0.76
Alsaadi G, Quirynen M, Michiles K, Teughels W, Komarek A & van Steenberghe D. 2008b[8]	2-	Dental implant (MkII TiUnite™) survival and factors related to early* failure. University setting. *early = before or up to abutment connection	238	720	No significant differences in failure rates in people with hypertension (1.68%) compared to people without (2%). p=1 Fisher; 0.82 GEE
Alvim-Pereira F, Montes C C, Thome G, Olandoski M & Trevilatto P C. 2008	2-	Relationship between vitamin D receptor gene polymorphism & other clinical factors with dental implant failure. NEODENT™ implants	217	1376	19.7% of 'no failure' group had cardiovascular disease compared to 26.3% in 'failure' group (p=0.310). Unadjusted OR = 1.45 (0.76-2.78)

Table 20. Effect of hypertension on dental implant failure.					
Reference	**LOE***	**Description**	**Numbers**		**Key Results**
			People	**Implants**	
		University setting			
Moy P K, Medina D, Shetty V & Aghaloo T L. 2005[21]	2-	Risk factors for implant failure. Various dental implant brands. University setting.	1140	4680	No significant difference in risk of failure between people with hypertension and those without. RR = 0.95 (95%CI: 0.62-1.46)

**LOE = level of evidence*

Effect of prosthesis type

Six papers[13, 17, 20, 30, 44] were reviewed that evaluated the effect of prosthesis type on implant survival/success, including five cohort studies and one case series (Table 21).

- One study[17] compared the risk of complications with a removable prosthesis compared to a fixed prosthesis and found that there was a non-significant increase in the risk of implant failure with removable prostheses (HR = 1.97)
- Another[20] found that those who had a removable prosthesis or a single tooth replacement were more likely to have implants fail (RR = 9.2 (p=0.04))
- However, the other studies[13, 23, 30, 44] found no significant difference in risk of implant failure with regard to the kind of prosthesis.

Discussion

Out of six studies, only one found a significant difference in the risk of implant failure depending on the type of prosthesis. The relative risk was also so large compared to the other studies' risk estimates that this result is likely due to bias, confounding or a chance finding (see evidence table for more details). Therefore, based on limited evidence, it is concludedthat prosthesis type ***per se*** is not a significant risk factor for implant failure.

Suggested evidence statement:
There is insufficient evidence that the type of prosthesis has any significant effect on risk of implant failure.

Table 21. Effect of prosthesis type on dental implant failure.					
Reference	**LOE***	**Description**	**Numbers**		**Key Results**
			People	**Implants**	
McDermott N E, Chuang S-K, Woo V V & Dodson T B.	2+	Types and frequencies of complications associated with implants AND to	677	677	No significant effect of prosthesis type (removable vs. fixed) on risk of overall complications* or inflammatory

Table 21. Effect of prosthesis type on dental implant failure.					
Reference	**LOE***	**Description**	**Numbers**		**Key Results**
			People	**Implants**	
2003[17]		identify risk factors associated with implant complications. Bicon dental implants. Hospital Dentistry Centre.			complications. *HR[adjusted] = 1.97 (95%CI: 0.92-4.21) p=0.083
McDermott N E, Chuang S-K, Woo V V & Dodson T B. 2006[44]	2+	Investigation of maxillary sinus augmentation as an independent risk factor for implant failure using multivariate analysis. Bicon dental implants. Hospital Dentistry Centre.	677	2349	No significant difference in risk of failure with different prostheses on multivariate analysis.
Moheng P & Feryn J-M. 2005[20]	2-	Biomarkers of bone turnover as predictors of implant failure and other factors that may be related to failure. Frialit-2® or IMZ® Twin Plus dental implants. Hospital Dental Implantology Centre.	93	266	Those who had a removable prosthesis or a single tooth replacement were more likely to have implants fail: RR = 9.2 (p=0.04)
Mundt T, Mack F, Schwahn C & Biffar R. 2006[13]	2-	Potential risk factors for implant failure. Tiolox dental implants. Private practice.	159	663	No significant difference in risk of failure with different prostheses: HR = 0.72 (95%CI:0.26-1.93)
Sanchez-Perez A, Moya-Villaescusa M J & Caffesse R G. 2007[30]	3	Risk of smoking with regards to implant success. Type of implant not reported. Private dental practice.	66	165	No significant statistical differences in success with regard to kind of prosthesis.
Woo V V, Chuang S-K, Daher S, Muftu A & Dodson T B. 2004[23]	2-	Assess the use of dentoalveolar reconstructive procedures as a risk factor for implant failure. Bicon dental implants. Hospital setting.	677	677	A non-significant increase in risk of implant failure in people with removable vs. fixed prostheses: HR = 1.3 (95%CI: 0.4-4.7) p=0.65

**LOE = level of evidence*

Effect of diabetes

Six papers[6, 8, 12, 13, 21, 29] were reviewed that evaluated the effect of diabetes on implant survival/success, including one systematic review, 4 cohort studies and one case series (Table 22). Eight narrative reviews and one consensus guideline are also included.

- In the systematic review[12], the survival rate was 91.7% (95%CI: 89.1-94.3%) in people with type II diabetes and 93.2% (95%CI: 92.2-94.1%) in people without diabetes. The authors could not calculate a pooled estimate for the difference in survival rates as there was only one study that included both diabetics and non-diabetics.

Of the 4 cohort studies,

- One[6] found no significant difference in risk of early implant failure in people with type II diabetes (OR = 0.25). There were no failures in the group of people with type I diabetes therefore any effect of this condition on implant failure could not be calculated

- Another,[21] found that people with diabetes had a greater risk of implant failure (RR = 1.94 p=0.003). Whether the participants had type I or II diabetes is not stated.

- Alsaadi (2008b)[8] reported a significantly greater risk of late failure in people with type I diabetes (p=0.02), however there was only one implant placed in a person with diabetes type I and it failed i.e. failure rate = 100%, an extremely unlikely true estimate of risk. When considering type II diabetes, there was no significant difference in the risk of implant failure (p=0.39 & 0.36)

- The last study[13] reported that 'diseases' (which included diabetes) were not significantly correlated with implant failure. Like the previous study, this result is unlikely to be of any validity.

The last two studies[29, 45] reported no significance difference in risk in people with diabetes; in the case-control study[45] the p-value was 0.096 and no statistics were reported in the case series[29].

Of the eight narrative reviews and one consensus guideline,

- Four of these reviews[35, 39, 41, 43] state that 'uncontrolled' diabetes is among the factors that contribute to an elevated risk of implant failure. The evidence base used to reach this conclusion is limited i.e. is based on only one or two studies and, at times, only on other narrative reviews

- Another[57] lists diabetes as increasing implant failure (citing one study) and slightly reducing implant success to between 86-96% (citing five studies)

- Paquette (2006)[38] reports from one study and concludes that "endocrine disease, particularly diabetes, may also pose a significant risk for implant failure"

- Hwang (2007)[56] conclude that if glycaemic control is adequate (according to the HbA1c level) diabetes does not compromise implant success

- In contrast, another review[42] and the guideline[34], could not come to a definitive conclusion about whether diabetes is a significant risk factor for implant failure.

Discussion

The concerns surrounding people with diabetes is that the condition may affect the circulation at the implant site, delaying healing time and also increase the risk of infection.[39]

The previous review[1] concluded that dental implants were a suitable for people with well-controlled diabetes type II who do not have any other risk factors for implant failure.

The studies reviewed here suggest that there is very little evidence that diabetes type II increases the risk of implant failure by any significant degree. The study with the largest numbers[6] (and the only one assessed as '2+') found no significant difference, however, the number of people with diabetes was not reported so it is not possible to estimate the power of the study to detect a difference. The systematic review[12], on the other hand, found an absolute difference in survival of 1.5% between those people with diabetes type II and those without; whether this is due to a 'true' effect, bias, confounding or chance cannot be ascertained with any certainty.

When considering the narrative reviews it is worth taking into account that often their conclusions are based on a very limited number of studies; the same studies have been used in different reviews; and, several reviews have used studies included in the previous ACC Dental Implant review.[1] This all contributes to the narrative reviews appearing to be a robust, large body of evidence when, in fact, they are based on very little evidence.

Suggested evidence statements:
There is insufficient evidence that well controlled diabetes* type II is a significant risk factor on its own for implant failure.
There is no evidence whether diabetes type I is or is not a risk factor for implant failure.

*measured by glycated haemaoglobin (HbA1c) blood test

Table 22. Effect of diabetes on dental implant failure.

Reference	LOE*	Description	Numbers		Key Results
			People	Implants	
Alsaadi G, Quirynen M, Komarek A & van Steenberghe D. 2007[6]	2+	Dental implant (Brånemark system®) survival and factors related to risk of early* failure. University setting. *early = before or up to abutment connection	2004	6946	No significant difference in risk of early failure in people with diabetes type II: OR = 0.25 (95%CI: 0.05-1.20) NB: could not evaluate effect of diabetes type I because no failures occurred in this group.
Alsaadi G, Quirynen M, Michiles K, Teughels W, Komarek A & van Steenberghe D. 2008b[8]	2-	Dental implant (MkII TiUnite™) survival and factors related to early* failure. University setting. *early = before or up to abutment connection	238	720	Significantly increased failure rate in people with type I diabetes (100%*) compared to 1.81% failed in people without diabetes type I; p=0.02 *only one implant & it failed No significant difference in implant failures in people with type II diabetes; p=0.39/0.36

Table 22. Effect of diabetes on dental implant failure.					
Reference	**LOE***	**Description**	**Numbers**		**Key Results**
			People	**Implants**	
Alvim-Pereira F, Montes C C, Thome G, Olandoski M & Trevilatto P C. 2008[45]	2-	Relationship between vitamin D receptor gene polymorphism & other clinical factors with dental implant failure. NEODENT™ implants University setting	217	1376	6.6% of 'no failure' group had diabetes compared to 1.3% in 'failure' group (p=0.096). Unadjusted OR = 1.45 (0.76-2.78)
Klokkevold P R & Han T J. 2007[12]	2-	Systematic review of the effect of smoking, diabetes & periodontitis on the survival or success of dental implants. (N=14 studies)	1150	10904	Diabetes: Type II only *Survival (4 studies)* • Diabetics = 91.7% (95%CI: 89.1-94.3%) • Non-diabetics = 93.2% (95%CI: 92.2-94.1%) Pooled estimate of the difference in survival rates not possible to calculate because only one study included both diabetic & non-diabetic patients. Implant success not reported in any of the studies.
Kourtis S G, Sotiriadou S, Voliotis S & Challas A. 2004[29]	3	Associate the causes of dental implant failure with some potential risk factors. Various implant brands. Private dental clinics (4).	405	1692	"No statistical significance was noted among failures in people with diabetes".
Moy P K, Medina D, Shetty V & Aghaloo T L. 2005[21]	2-	Risk factors for implant failure. Various dental implant brands. University setting.	1140	4680	People with diabetes have an increased chance of implant failure: RR = 1.94 p=0.003
Mundt T, Mack F, Schwahn C & Biffar R. 2006[6, 13]	2-	Potential risk factors for implant failure. Tiolox dental implants. Private practice.	159	663	Reported that 'diseases' were not significantly correlated with implant failure ('diseases' included: cardiovascular diseases, allergies, blood clotting disorders, diabetes, hepatitis, tuberculosis, HIV, thyroid diseases, osteoporosis, arthritis/arthrosis, & rheumatism).

**LOE = level of evidence*

Effect of asthma or pulmonary disease

Three cohort studies[6-8, 21] were reviewed that evaluated the effect of asthma or pulmonary disease on implant survival/success (Table 23).

None of the cohort studies found a significant effect of asthma on implant failure:

- Alsaadi (2007)[6] found no effect of the presence of asthma on the risk of early implant failure (OR = 1.92)
- Alsaadi (2008a)[7] found no effect of asthma on late implant failure (OR = 2.55)
- Alsaadi (2008b)[8] found that the presence of asthma did not increase the failure rate
- Moy (2005)[21] reported that pulmonary disease did not have a significant effect on implant failure (RR = 0.87).

Discussion

The evidence reviewed here is very limited and involves small numbers of people but is consistent: asthma did not significantly increase the risk of implant failure.

Suggested recommendation:
There is no evidence that asthma is a significant risk factor for implant failure on its own.

Table 23. Effect of asthma on dental implant failure.

Reference	LOE*	Description	Numbers		Key Results
			People	Implants	
Alsaadi G, Quirynen M, Komarek A & van Steenberghe D. 2007[6]	2+	Dental implant (Brånemark system®) survival and factors related to risk of early* failure. University setting. *early = before or up to abutment connection	2004	6946	No effect of asthma on the risk of early implant failure: OR = 1.92 (95%CI: 0.37-9.97)
Alsaadi G, Quirynen M, Komarek A & van Steenberghe D. 2008a[7]	2-	Dental implant (Brånemark system®) survival and factors related to risk of late* failure. University setting. *late = after occlusal loading is established	412	1514	No effect of asthma on the risk of late implant failure: OR = 2.55 (95%CI: 0.65-10.01) p=0.18
Alsaadi G, Quirynen M, Michiles K, Teughels W, Komarek A & van Steenberghe D. 2008b[8]	2-	Dental implant (MkII TiUnite™) survival and factors related to early* failure. University setting. *early = before or up to	238	720	The presence of asthma "did not lead to an increased risk of early implant failure." Failure rates: 1.86% (no asthma) vs. 4.55% (asthma) p=0.36; 0.39

Table 23. Effect of asthma on dental implant failure.					
Reference	**LOE***	**Description**	**Numbers**		**Key Results**
			People	**Implants**	
		abutment connection			
Moy P K, Medina D, Shetty V & Aghaloo T L. 2005[21]	2-	Risk factors for implant failure. Various dental implant brands. University setting.	1140	4680	Reported as not significant. NB "pulmonary disease" reported as having a RR = 0.87 (95%CI: 0.44-1.73)

**LOE = level of evidence*

Effect of rheumatoid arthritis

Four cohort studies[6-8, 13] and one case-control study[45] were reviewed that evaluated the effect of rheumatoid arthritis on implant survival/success (Table 24).

- Three of the cohort studies[6-8] could not evaluate the risk of implant failure as there were no implant failures in people with rheumatoid arthritis in any of these papers
- The other cohort study[13] reported that "diseases", which included rheumatoid arthritis, had no effect on implant failure
- The case-control study[45] reported that there was no significant increase in risk of implant failure (OR = 1.36).

Discussion

Essentially the evidence is based on only one study and that found no significant increase in the risk of implant failure.

Suggested evidence statement:
There is no evidence that rheumatoid arthritis is a significant risk factor for implant failure.

Table 24. Effect of rheumatoid arthritis on dental implant failure.					
Reference	**LOE***	**Description**	**Numbers**		**Key Results**
			People	**Implants**	
Alsaadi G, Quirynen M, Komarek A & van Steenberghe D. 2007[6]	2+	Dental implant (Brånemark system®) survival and factors related to risk of early* failure. University setting. *early = before or up to abutment connection	2004	6946	Could not evaluate as no failures in this group.

Table 24. Effect of rheumatoid arthritis on dental implant failure.					
Reference	**LOE***	**Description**	**Numbers**		**Key Results**
			People	**Implants**	
Alsaadi G, Quirynen M, Komarek A & van Steenberghe D. 2008a[7]	2-	Dental implant (Brånemark system®) survival and factors related to risk of late* failure. University setting. *late = after occlusal loading is established	412	1514	Could not evaluate as no failures in this group.
Alsaadi G, Quirynen M, Michiles K, Teughels W, Komarek A & van Steenberghe D. 2008b[8]	2-	Dental implant (MkII TiUnite™) survival and factors related to early* failure. University setting. *early = before or up to abutment connection	238	720	Could not evaluate as no failures in this group.
Alvim-Pereira F, Montes C C, Thome G, Olandoski M & Trevilatto P C. 2008[45]	2-	Relationship between vitamin D receptor gene polymorphism & other clinical factors with dental implant failure. NEODENT™ implants University setting.	217	1376	No significant difference in the rate of people with rheumatoid arthritis in each group (19.7% in the 'no failure group' vs. 25% in the 'at least 1 failure' group). p=0.395 Unadjusted OR = 1.36 (95%CI: 0.70-2.62)
Mundt T, Mack F, Schwahn C & Biffar R. 2006[13]	2-	Potential risk factors for implant failure. Tiolox dental implants. Private practice.	159	663	"Diseases" reported as having no effect on implant failure.

**LOE = level of evidence*

Effect of thyroid disease

Five papers[6-8, 13, 45] were reviewed that evaluated the effect of thyroid disease on implant survival/success, including four cohort and one case-control study (Table 25). Two narrative reviews are also included.

All the studies found that thyroid disease did not increase the risk of implant failure significantly:

- Alsaadi (2007)[6] found no significant effect of hypo- or hyperthyroidism on the risk of early implant failure (OR = 1.00 & 1.40 respectively)
- Alsaadi (2008a)[7] reported no significant effect of hypo- or hyperthyroidism on the risk of late implant failure (OR = 0.95 & 0.57 respectively)

- Alsaadi (2008b)[8] reported that the presence of thyroid disease "did not lead to an increased risk of early implant failure." However there were no failures in either the hypo- or hyperthyroid groups
- The case-control study[45] found no significant increase in risk of implant failure (OR = 1.32)
- As stated previously in this review, Mundt (2006)[13] reported that "diseases", including thyroid disease, had no significant effect on implant failure.

Two narrative reviews[38, 56] mention hypothyroidism and dismiss it as a relevant risk factor for implant failure. These conclusions are based on only two studies (one of which was included in the previous dental implant review[1]).

Discussion

Effectively, the evidence is based on only three studies[6, 7, 45], all with low sample sizes and wide confidence intervals.

Suggested evidence statement:
There is insufficient evidence that thyroid disease is a significant risk factor for implant failure.

Table 25. Effect of thyroid disease on dental implant failure.

Reference	LOE*	Description	Numbers		Key Results
			People	Implants	
Alsaadi G, Quirynen M, Komarek A & van Steenberghe D. 2007[6]	2+	Dental implant (Brånemark system®) survival and factors related to risk of early* failure. University setting. *early = before or up to abutment connection	2004	6946	No significant effect of hypo- or hyperthyroidism on the risk of early implant failure: OR [hypo] = 1.00 (95%CI: 0.32-3.16) OR [hyper] = 1.40 (95%CI: 0.007-26.51)
Alsaadi G, Quirynen M, Komarek A & van Steenberghe D. 2008a[7]	2-	Dental implant (Brånemark system®) survival and factors related to risk of late* failure. University setting. *late = after occlusal loading is established	412	1514	No significant effect of hypo- or hyperthyroidism on the risk of late implant failure: OR [hypo] = 0.95 (95%CI: 0.29-3.02); p=0.93 OR [hyper] = 0.57 (95%CI: 0.03-12.99); p=0.73
Alsaadi G, Quirynen M, Michiles K, Teughels W, Komarek A & van Steenberghe D. 2008b[8]	2-	Dental implant (MkII TiUnite™) survival and factors related to early* failure. University setting. *early = before or up to	238	720	The presence of thyroid disease "did not lead to an increased risk of early implant failure." NB no failures in the hypo- or hyperthyroid group.

Table 25. Effect of thyroid disease on dental implant failure.					
Reference	**LOE***	**Description**	**Numbers**		**Key Results**
			People	**Implants**	
		abutment connection			
Alvim-Pereira F, Montes C C, Thome G, Olandoski M & Trevilatto P C. 2008[45]	2-	Relationship between vitamin D receptor gene polymorphism & other clinical factors with dental implant failure. NEODENT™ implants University setting.	217	1376	No significant difference in the rate of people with hypothyroidism in each group (8.8% in the 'no failure group' vs. 11.3% in the 'at least 1 failure' group). p=0.636 Unadjusted OR = 1.32 (95%CI: 0.53-3.29)
Mundt T, Mack F, Schwahn C & Biffar R. 2006[13]	2-	Potential risk factors for implant failure. Tiolox dental implants. Private practice.	159	663	"Diseases" reported as having no effect on implant failure.

**LOE = level of evidence*

Effect of medication and other factors

Seven papers (five cohort, one case-control & one case series) were reviewed that evaluated the effect of other factors, including any 'systemic' disease, metabolic disease, a "medically compromising condition" or any medical condition, or medication (Table 26). Three narrative reviews mentioned bisphosphonate therapy[43, 56, 57].

Medical conditions:

- The case-control study[45] found no differences in the proportions of people with a systemic disease in either group
- The three cohort studies[13, 27, 53] found no association between having a 'medically compromising condition'[53], 'diseases'[13] (including cardiovascular disease, allergies, blood clotting disorders, diabetes, hepatitis, TB, HIV, thyroid disease, osteoporosis, rheumatism, and arthritis/arthrosis) or a past history of any medical condition and dental implant failure[27]
- In contrast, the case series[29] found that more implants failed in people who had a metabolic disease ($p<0.001$).

Medications:

- Three studies[8, 21, 45] concluded that taking steroid medication was not associated with implant failure
- Alvim-Pereira (2008)[45] also found no association between taking no medication, or taking anti-hypertensive, statin, antimicrobial, non-steroidal anti-inflammatory or hormone replacement medication and risk of implant failure
- Alsaadi (2008b)[8] also found no association between taking antidepressant medication and implant failure

- In regard to antibiotics, one study[8] found no relationship between taking antibiotics at the time of implant surgery and implant failure, another[27] found that people who were allergic to penicillin had a greater failure rate than those people who were not, but the statistical significance is unclear

- Wagenberg and Froum (2006)[27] also found no correlation between implant failure and taking any single medication or combination of medications.

- All three narrative reviews[43, 56, 57] stated that sytemic bisphosphonate medication was a contraindication to implant placement due to the risk of osteonecrosis of the jaw.

Discussion

All of the studies, except one case series[29], found no association between various 'diseases' and implant failure. In addition, no association was found with steroid, antidepressant, antihypertensive, statin, antimicrobial or non-steroidal anti-inflammatory medications. However, there is a strong consensus that bisphosphonate medications are a contraindication to implant placement due to the risk of osteonecrosis of the jaw.

Most of the variables investigated in these studies were not the primary focus of the respective studies, consisted of small numbers of people and were rather crude measures – all of which jeopardises the validity of the findings for these 'secondary' exposures of interest.

Suggested evidence statement:
There is insufficient evidence that any medical condition (other than those already evaluated in this review) is a significant risk factor for implant failure.
There is insufficient evidence that steroid, antidepressant, antihypertensive, statin, antimicrobial or non-steroidal anti-inflammatory medications are a significant risk factor for implant failure.
Bisphosphonate medication is a contraindication to implant placement due to the risk of osteonecrosis of the jaw.

Table 26. Effect of miscellaneous factors on dental implant failure.

Reference	LOE*	Description	Numbers		Key Results
			People	Implants	
Medical conditions					
Alvim-Pereira F, Montes C C, Thome G, Olandoski M & Trevilatto P C. 2008[45]	2-	Relationship between vitamin D receptor gene polymorphism & other clinical factors with dental implant failure. NEODENT™ implants University setting	217	1376	No significant differences in proportion with a systemic disease between the 'no failures' group and 'at least 1 failure' group. Unadjusted OR = 0.95 (95%CI: 0.52-1.73)
Gentile M A, Chuang S-K &	2-	Survival of Bicon implants and risk factors associated	35	172	No significant increase in risk of failure in people who had a medically compromising

Table 26. Effect of miscellaneous factors on dental implant failure.					
Reference	**LOE***	**Description**	**Numbers**		**Key Results**
			People	**Implants**	
Dodson T B. 2005[53]		with implant failure. Bicon 6x5.7mm dental implants. Hospital setting.			condition: HR=0.4 (95%CI: 0.0-4.2) p=0.46 ASA* status had no effect on risk of implant failure: HR = 0.6 (95%CI: 0.2-1.3) p=0.20 *a measure of health status
Kourtis S G, Sotiriadou S, Voliotis S & Challas A. 2004[29]	3	Associate the causes of dental implant failure with some potential risk factors. Various implant brands. Private dental clinics (4).	405	1692	More implants failed in those with metabolic diseases e.g. thyroid gland dysfunction (p<0.001).
Mundt T, Mack F, Schwahn C & Biffar R. 2006[13]	2-	Potential risk factors for implant failure. Tiolox dental implants. Private practice.	159	663	"Diseases" (cardiovascular disease, allergies, blood clotting disorders, diabetes, hepatitis, TB, HIV, thyroid disease, osteoporosis, rheumatism, and arthritis/arthrosis) reported as having no effect on implant failure.
Wagenberg B & Froum S J. 2006[27]	2-	Risk factors for implant failure.	891	1925	No correlation between implant failure & past history of any medical condition (p=0.967).
Medications					
Alsaadi G, Quirynen M, Michiles K, Teughels W, Komarek A & van Steenberghe D. 2008b[8]	2-	Dental implant (MkII TiUnite™) survival and factors related to early* failure. University setting. *early = before or up to abutment connection	238	720	Steroid & antidepressant medication "did not lead to an increased incidence in the early failures (p>0.05)." Taking antibiotics at the time of implant surgery was not related to implant failure (p=1.00 Fisher; 0.95 GEE).
Alvim-Pereira F, Montes C C, Thome G, Olandoski M & Trevilatto P C. 2008[45]	2-	Relationship between vitamin D receptor gene polymorphism & other clinical factors with dental implant failure. NEODENT™ implants University setting	217	1376	No significant differences in risk of failure when taking: no medication (p=0.777), • OR* = 0.90 (95%CI: 0.51-1.56) anti-hypertensives (p=0.379), • OR = 1.37 (95%CI: 0.69-2.71) antimicrobials (p=0.999), • OR = 1.10 (95%CI: 0.41-2.96) non-steroidal anti-inflammatory (p=0.219), • OR = 2.14 (0.63-7.25) steroids (p=0.710), • OR = 1.30 (95%CI: 0.28-5.94) hormone replacement (p=1), • OR = 1.01 (95%CI: 0.51-1.97) statins (p=0.999)

Table 26. Effect of miscellaneous factors on dental implant failure.					
Reference	**LOE***	**Description**	**Numbers**		**Key Results**
			People	**Implants**	
					• OR = 1.15 (95%CI: 0.31-4.20) * all unadjusted odds ratios
Moy P K, Medina D, Shetty V & Aghaloo T L. 2005[21]	2-	Risk factors for implant failure. Various dental implant brands. University setting.	1140	4680	Steroid medication was not related to a change in the risk of implant failure: RR = 0.73 (95%CI: 0.36-1.49)
Wagenberg B & Froum S J. 2006[27]	2-	Risk factors for implant failure.	891	1925	No correlation between implant failure & any single medication or combination of medications (p=0.895). Participants who were allergic to penicillin had a greater failure rate (8.52%) than those not allergic (2.95%). Statistical significance is unclear.

**LOE = level of evidence*

Additional Information

In addition to the studies evaluated so far, patient selection criteria from one consensus guideline[34] and five narrative reviews[39, 43, 56-58] are given below for consideration.

A 2008 narrative review[43] of literature with references to patient assessment contained a table (Table 27) of contraindications and increased risk for implant failure.

Table 27: Contraindications and increased risk for implant failures

	Disease	***Assessment***
Medical contraindications	• acute infectious diseases	– absolute, but temporarily; wait for recovery
	• chemotherapy	– absolute, but temporarily; reduced immune status
	• systemic bisphosphonate medication (≥2 yr)	– risk of bisphosphonate-induced osteonecrosis (BON)
	• renal osteodystrophia	– increased risk for infection, reduced bone density
	• severe psychosis	– absolute; risk of regarding the implant as a foreign body and requesting removal despite successful osseointegration
	• depression	– relative
	• pregnancy	– absolute, but temporarily; to avoid additional stress and radiation exposure
	• unfinished cranial growth with incomplete tooth eruption	– relative but temporarily; to avoid any harm to the growth plates, to avoid inadequate implant position relative to the residual dentition; utilise hand-wrist radiograph to evaluate end of skeletal growth single tooth implants in the anterior region not before 25th yr of age
Intra-oral contraindications	• pathologic findings at the oral soft and/or hard tissues	– temporarily; increased risk for infection, wait until healing is completed
Increased risk for implant failure	• post-head and neck radiation therapy	– reduced bone remodelling, risk of osteoradionecrosis, implant placement 6-8 weeks before or ≥1 yr after radiotherapy
	• osteoporosis	– reduced bone to implant contact; consider calcium substitution, prolong healing period and avoid high torque levels for abutment screw fixation
	• uncontrolled diabetes	– eventually wound healing problems (impaired immunity, microvascular diseases)
	• status post-chemotherapy, immuno-suppressants, or steroid long-term medication, HIV infection	– eventually wound healing problems, medical advice required (consider corticosteroid cover)
	• alcohol and drug abuse, heavy smoking ≥20 cig/d	– eventually wound healing problems, locally reduced vascularisation
	• history of aggressive periodontitis	– increased risk to develop peri-implantitis

Adapted from Zitzmann 2008[43]

In an earlier (2005) narrative review[39] of the predictors of dental implant success or failure, the authors presented their conclusions in the table below (Table 28).

Table 28: Predictors of implant success or failure.

Positive factors	***Negative factors***
Bone type (Types 1 and 2)	Bone type (Types 3 and 4)
High bone volume	Low bone volume
Patient is less than 60 years old	Osteonecrosis
Clinician experience (more than 50 cases)	Patient is more than 60 years old
Mandibular placement	Limited clinician experience
Single tooth implant	Systemic diseases (for example, uncontrolled diabetes)
Implant length >0.8 mm	Auto-immune disease (for example, lupus or HIV)
Fixed partial denture with more than two implants	Chronic periodontitis
Axial loading of implant	Smoking and tobacco use
Regular postoperative recalls	Unresolved caries, endodontic lesions, frank pathology
Good oral hygiene	Maxillary placement, particularly posterior region
	Short implants (<0.7 mm)
	Acentric loading
	Inappropriate early clinical loading
	Fixed partial denture with two implants
	Bruxism and other parafunctional habits

Adapted from Porter 2005[39]

Another narrative review[57] summarised the current evidence for the risks associated with dental implants in a range of systemic disorders in the table below (Table 29).

Table 29. Implant use in medically compromised patients

Condition	Evidence that condition is a contraindication to implants	Implant success rate compared to that in healthy population[†]	Other considerations	Management modifications that may be indicated
Alcoholism	-	Similar (5)	Tobacco use; Bleeding tendency; Osteoporosis; Impaired immunity; Malnutrition; Behavioural problems	May not be a good risk group
Bleeding disorder	Medical advice should be taken first	Similar (5)	Possibility of blood borne infections	May not be a good risk group Medical advice should be taken first
Bone disease (osteoporosis, osteopaenia)	-	Similar (4)	-	Sinus lifts may be contraindicated Bisphosphonate therapy is a contraindication to endosseous implants
Cardiac disease	Medical advice should be taken first	Similar (5)	May be anticoagulated, poor candidates for general anaesthesia	Avoid general anaesthesia Assess endocarditis prophylaxis
Corticosteroid therapy	-	Similar (5)	May be impaired immunity	Parenteral corticosteroid cover unless quite confident that collapse unlikely Consider antimicrobial prophylaxis
Crohn's disease	Impaired soft tissue healing	Similar (4)	Microvascular disease Osteoporosis	Consider antibiotic prophylaxis
Diabetes mellitus	Increased implant failure Medical advice should be taken first in insulin treated patients	Slightly reduced (2a)	May be blood borne infections	Avoid hypoglycaemia Use chlorhexadine Consider antibiotic prophylaxis
Immunocompromised patients	Medical advice should be taken first	Similar (4)	-	Use chlorhexadine Consider antibiotic prophylaxis
Mucosal disease	-	Similar (4)	Behavioural problems	-
Neuropsychiatric disorders	Medical advice should be taken first	Similar (4)	Prognosis	-
Oncology: radiotherapy	-	Reduced (1b) Similar (3b)	Prognosis	Surgery 21 days before DXR DXR < 50 Gy Hyperbaric oxygen Defer implants 8 months Consider antimicrobial cover
Oncology: chemotherapy	-	Reduced (1b) Similar (3b)	-	Surgery best completed before chemotherapy Consider antimicrobial cover Bisphosphonate therapy is a contraindication to endosseous implants
Sjögren's syndrome	-	Similar (4)		-

[†]Levels of evidence.

1a, series of randomised clinical trials; 1b, individual randomised clinical trials; 1c, all or none case series; 2a, series of cohort studies; individual cohort studies; 2c, “outcomes” research; 3a, series of case-control studies; individual case-control studies; 4, case series and other descriptive studies; 5, reports of expert committees and opinions of respected authorities, based on clinical experience.

Two narrative reviews of the literature, Hwang (2006[58] & 2007[56]) list both the absolute and relative contraindications to implant therapy.

The absolute contraindications include:

- recent myocardial infarction and cerebrovascular accident
- valvular prosthesis surgery
- immunosuppression
- bleeding issues
- active treatment of malignancy
- drug abuse
- psychiatric illness
- intravenous bisphosphonate use.

The relative contraindications include:

- adolescence
- aging
- osteoporosis
- smoking
- diabetes
- positive interleukin-1 genotype
- being HIV positive
- cardiovascular disease
- hypothyroidism.

In a consensus guideline developed by the Academy of Osseointegration[59] based on the results their 2006 Consensus Conference on the State of the Science on Implant Dentistry, the potential risk factors for implant failure were discussed. They concluded that:

- Smoking had an adverse effect on implant survival and success, especially in areas of trabecular bone.
- Type II diabetes may have an adverse effect on survival rates, although the limited number of studies on diabetes precluded a definitive conclusion.
- A history of treated periodontitis did not appear to affect implant survival rates adversely but periodontitis may have a negative effect on implant success rates, particularly over longer periods. The authors recommended that a periodontal evaluation and appropriate treatment be provided prior to implant placement.

- Several grafting procedures have proven successful in providing adequate bone quantity and quality in patients who have bone loss. The long-term (>5yrs) clinical success/survival of implants placed after maxillary sinus augmentation, regardless of grafting materials, compared favourably to implant placed with no grafting procedure.

Conclusions

It is concluded that dental implants are a successful intervention to replace teeth in University settings. Due to the relatively poor quality of the papers reviewed, guideline development will rely on consideration of the existing evidence, expert opinion and consensus.

The evidence for significant risk factors for implant failure is summarised, as follows:

- Smoking as a single risk factor may not increase the risk of failure sufficiently to deny treatment but dental implants may be contra-indicted in smokers who have other relevant risk factors. In addition, smokers seeking dental implant treatment should have their smoking history taken, be advised of the risk of implant failure and advised to stop smoking.

- Even though there is insufficient evidence that people with a history of treated periodontitis have a significantly elevated risk of implant failure, the consensus view is that people with periodontitis should be treated for this condition before being considered for implant therapy.

- In addition, even though there is insufficient evidence that oral health status or oral hygiene behaviour has a significant effect on the risk of implant failure, the consensus view is that people with poor oral hygiene, infection or uncontrolled caries should not be offered dental implants.

- There is weak evidence that dental implants placed in the maxilla may have a greater risk of failure.

- There is some weak evidence that implants placed after maxillary sinus augmentation may have an increased risk of failure but there is no evidence that other bone graft/augmentation techniques alter significantly the risk of implant failure.

- Older age, as a single risk factor, is not a contraindication for implant placement.

- There is a consensus opinion that implant placement should be delayed in young people until growth is complete

- There is some evidence that implant failure rates in the maxilla are usually significantly increased in people who have previously had irradiation of the jaw, regardless of the total radiation dose.

- There is a consensus opinion that dental implants should not be placed in people undergoing active chemotherapy.

- Medical advice should be sought for people with coagulation disorders or taking anticoagulant medication before proceeding with implant placement.

- Bisphosphonate medication is a contraindication to implant placement due to the risk of osteonecrosis of the jaw.
- There is insufficient evidence that well controlled diabetes type II is a significant risl factor for implant failure
- There is no evidence whether diabetes type I, asthma, rheumatoid arthritis is or is not a significant risk factor for implant failure
- There is insufficient evidence that the following factors are significant risk factors for implant failure:
    - type of edentulousness or proximity to natural dentition
    - placement in the posterior region of a jaw
    - osteoporosis
    - type of prosthesis
    - a history of chemotherapy treatment
    - cardiovascular disease, including hypertension and hypercholesterolaemia
    - thyroid disease, gastric problems or Crohn's disease
    - hormone replacement therapy, menopausal status or history of a radical hysterectomy
    - steroid, antidepressant, antihypertensive, statin, antimicrobial or non-steroidal anti-inflammatory medications.

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Appendix A:

Patient Factors:

MEDLINE

1. exp Dental Implants/px, ct [Psychology, Contraindications]
2. exp Dental Implants/
3. ((dental or tooth) adj implant$).mp.
4. exp Decision Making/
5. exp Patient Selection/
6. exp Dentist-Patient Relations/
7. Judgment/
8. (patient selection or patient characteristics or psychological factor$).mp.
9. or/4-8
10. (2 or 3) and 9
11. 10 or 1
12. limit 11 to human

EMBASE

1. exp Tooth Implantation/
2. ((dental or tooth) adj implant$).af.
3. exp Decision Making/
4. exp Patient Selection/
5. exp Psychological Aspect/
6. exp TREATMENT CONTRAINDICATION/
7. exp TREATMENT INDICATION/
8. (patient selection or patient characteristics or psychological factor$).af.
9. or/3-8
10. (1 or 2) and 9

PREMEDLINE

1. ((dental or tooth) adj implant$).af.
2. (patient selection or patient characteristics or psychological factor$).af.
3. (contraindication$ or indication$ or risk factor$).af.
4. 1 and (2 or 3)

CINAHL

1. exp Dental Implants/
2. ((dental or tooth) adj implant$).mp.
3. exp Decision Making/
4. exp Patient Selection/
5. exp Dentist-Patient Relations/

6. Judgment/
7. exp Risk Factors/
8. Psychosocial Aspects of Illness/
9. (patient selection or patient characteristic$ or contraindication$ or psychological factor$).mp.
10. exp Patients/
11. or/3-10
12. (1 or 2) and 11

All EBM Reviews (Cochrane DSR, ACP Journal Club, DARE, CCTR)

exp dental implants/
(((dental or tooth) adj implant$) or (branemark or stereos)).mp.
or/1-2
exp decision making/
exp patient selection/
exp dentist-patient relations/
exp judgment/
exp risk factors/
(patient selection or patient characteristic$ or contraindication$ or risk factor$ or psychological factor$).mp.
or/4-9
3 and 10

PsycINFO

((dental or tooth or teeth) and implant$).af.
prosthodontic$.mp. not 2 [mp=title, abstract, heading word, table of contents, key concepts]
1 or 2

Risk Factors:

MEDLINE

1. exp Risk Factors/
2. exp Dental Implants/
3. ((dental or tooth) adj implant$).af.
4. risk factor$.af.
5. (1 or 4) and (2 or 3)

EMBASE

1. exp Risk Factor/
2. risk factor$.af.
3. exp Tooth Implantation/
4. ((dental or tooth) adj implant$).af.
5. (1 or 2) and (3 or 4)

Appendix B:

Evidence Based Healthcare Table

Reference: Alsaadi 2007 **Bibliographic Number: 5**

Design	Participants	Exposures (total patients/implants)	Outcomes
Retrospective cohort **Biases/weaknesses:** Age not reported or adjusted for ~17% implants not included in multivariate analysis Type of edentulism and PTV value still possible confounders Oral status e.g. presence of periodontitis, & oral hygiene habits not accounted for as potential confounders	**Description:** N=2004 consecutive patients "from the total patient population" who had had 6946 dental implants placed between 1982-2003 at a single university department in Belgium. **Group:** Mean Age: not reported Gender: 1212 women, 792 men Implants: Brånemark system® (6316 machined & 630 Ti-Unite® surface) Drop-outs: Unable to get records for 12% (232/2004) patients with 17% implants Follow-up = 21yrs Setting: University Reliability of surgical records tested by comparing with medical records (700 people) **Inclusions:** Those patients with full records available. **Exclusions:** Patient files could not be retrieved. **Selection Notes:** • Failure = peri-implant radiolucency on intra-oral X-rays; implants showed slightest sign of mobility measured by PTV ≥ 5 or patient showed subjective signs of infection or pain that required removal. • Logistic regression analysis was used: univariate effect then multivariate effect for those that were univariately significant at 5% i.e. smoking, implant length/diameter/location, bone quantity/quality. NB type of edentulism and PTV not used as only available for a limited number of patients. • Generalising estimating equation (GEE) used to account for that repeated observations (several implants) were available for a single participant • For the multivariate analysis, implants with missing data on bone quality and quantity were removed (1100 implants). Also, it was not possible to statistically evaluate effect of chemotherapy, diabetes type I and	• Smoking, hypertension, ischaemic cardiac problems, coagulation anomalies, gastric problems, osteoporosis, hypo- or hyperthyroidism, hypercholesterolaemia, asthma, diabetes type I or II, Crohn's disease, rheumatoid arthritis, chemotherapy and medications (2004/6946). • Implant length (2004/6946) • Implant diameter (2004/6936) • Implant location (2000/6931) • Bone quantity (1759/5800) • Bone quality (1759/5782) • Type of edentulism (676/2448) • Antibiotics pre- or immediately after surgery (not reported) • Dehiscence during surgery (430/1380) • Perforation of jaw during surgery (418/1345) • Periotest® value (71/189) • Placement torque measurement (138/320)	**Outcome Measures:** Overall success rate (%) Odds of early implant failure* (OR; 95%CI; p-value) *Early failure = before or up to abutment connection **Results:** Overall success rate: 96.4% 252/6946 implants failed 1-6 months after placement (3.6%) in 178 patients. Odds of early implant failure: Univariate analysis: • Implant location OR [posterior mandible vs. anterior mandible] = 1.99 (1.29-3.07) OR [posterior maxilla vs. anterior mandible] = 1.88 (1.196-2.940) p=0.008 • Smoking OR [<10 cigs/day vs. none] = 1.42 (0.48-4.23) OR [10-20 cigs vs. no cigs] = 1.87 (1.07-3.26) OR [>20 vs. 0] = 2.72 (1.63-4.54) p<0.001 • Type of edentulism OR [implants neighbouring teeth vs. implants in full edentulism] = 2.77 (1.45-5.28) OR [implants neighbouring teeth vs. implants in the presence of teeth in antagonistic jaw only] = 4.879 (1.59-15.11) p<0.001 • Bone quantity OR [grade E vs. grade A] = 3.43 (1.49-7.89)

	rheumatoid arthritis as there were no failures in these groups. • No statistical difference between failure rate of both type of implant surface (p>0.05) therefore all implants grouped together.		OR [grade E vs. grade B] = 5.21 (2.34-11.61) OR [grade E vs. grade C] = 3.90 (1.73-8.79) p=0.002 • Bone quality OR [grade 4 vs. grade 2] = 3.05 (1.73-5.38) OR [grade 2 vs. grade 1] = 0.42 (0.23-0.77) p<0.001 Multivariate analysis: (controlled for smoking, bone quality/quantity, implant site, length & diameter) • Osteoporosis OR = 2.88 (1.51-5.48) p=0.001 • Crohn's disease OR = 7.95 (3.47-18.24) p<0.001 • Implant location OR [anterior vs. posterior] = 1.81 (1.30-2.53) p<0.001 • Smoking OR [>20 vs. 0] = 2.18 (1.20-3.97) OR [10-20 vs. 0] = 1.90 (1.007-3.60) OR [<10 vs. 0] = 1.76 (0.06-5.16) p=0.02 • Other factors e.g. antidepressant medication, asthma, bone quality, bone quantity, cardiac problem, claustrophobia, coagulation, diabetes type II, gastric problem, hypercholesterolaemia, hypertension, hyperthyroid, hypothyroid, radiotherapy, steroid medication –no statistically significant differences in risk of failure
			Methodological Score: **2+**

Evidence Based Healthcare Table

Reference: Alsaadi 2008a **Bibliographic Number: 6**

Design	Participants	Exposures	Outcomes
Retrospective cohort **Biases/weaknesses:** Method of random selection not reported Baseline demographic data not reported Loss to follow-up not reported Bone quality, PTV & abutment connection still possible confounders	**Description:** 700 patients, selected randomly from the total patient group (total not reported) treated with endosseous Brånemark® implants at the Dept of Periodontology of the University Hospital of the Catholic University Leuven. N= 412 patients with 1514 implants met inclusion criteria 412/700 (58.9%) patients included Age: not reported Gender: 240 (58.3%) women Follow-up period: 2yrs Setting: University **Inclusions:** • All implants not lost before or at abutment surgery i.e. 'late' failures • Implants for which it was possible to evaluate its status 2yrs after abutment surgery. **Exclusions:** • Implants that failed before or at abutment surgery ('early loss') • Patients who could not be followed for up to the 2yrs after abutment surgery. **Selection Notes:** • Failure = peri-implant radiolucency, mobility corresponding to a PTV (Periotest® value) of >5, or subjective sign of pain or infection, therefore 'failure' = lost implant i.e., removed • Because no implant loss was observed in those with diabetes, RA, claustrophobia or those taking chemotherapy or steroids, the effect of these factors could not be assessed • Bone quality, PTV at implant placement and abutment connection not controlled for because data was available for only a limited subgroup	Implant factors: • jaw (mandible, maxilla) • site (anterior, posterior) • location (jaw-site) • length • diameter • surface Health factors: • smoking (<10cigs/day; 10-20 cigs/day; >20cigs/day) • hypertension • ischaemic heart problems • coagulation anomalies • gastric problems e.g. ulcers • osteoporosis • hypo- or hyperthyroidism • hypercholesterolaemia • asthma • diabetes type I or II • Crohn's disease • rheumatoid arthritis • chemotherapy • medication e.g. antidepressants, steroids • local bone factors e.g. radiotherapy of the maxillofacial region • claustrophobia • type of edentulism (full edentulism, teeth present only in antagonistic jaw, teeth present in same jaw as implants and either	**Outcome Measures:** Overall success/survival rate (%) Odds of late implant failure* (OR) **Late failure = after, but not including, abutment connection* **Results:** Overall success/survival rate: 93.3% 101/1514 implants failed between abutment connection and the 2yrs follow-up Odds of late implant failure: Univariate analysis: • *Jaw* OR [maxilla vs. mandible] = 2.59 (1.50-4.49) p <0.001/adjusted p = 0.006 • *Site* OR [posterior vs. anterior] = 2.14 (1.427-3.208) p <0.001/adjusted p = 0.003 • *Location* OR [posterior mandible vs. anterior mandible] = 3.42 (1.29-9.06) OR [anterior maxilla vs. anterior mandible] = 3.99 (1.58-10.07) OR [posterior maxilla vs. anterior mandible] = 6.83 (2.65-17.57) p <0.001/adjusted p = 0.003 • *Smoking, type of edentulism, dehiscence/fenestration, bone quality*/quantity, implant length/diameter/surface* - all not significant **OR [grade 4 vs. grade 2] = 3.92 (1.51-10.21)* Multivariable GEE logistic regression:

		close to or not to implant)	• *Radiotherapy* OR = 3.32 (1.49-7.35) p=0.003 • *Location* OR [posterior mandible vs. anterior mandible] = 3.86 (1.41-10.54) OR [posterior mandible vs. anterior maxilla] = 3.9 (1.49-10.22) OR [posterior mandible vs. posterior maxilla] = 7.1 (2.69-18.78) p<0.001 • *Implant diameter, hypertension, cardiac/gastric/coagulation problem, osteoporosis, hypo- or hyperthyroidism , Crohn's disease , antidepressant medication, hypercholesterolaemia or asthma* - all not significant
			Methodological Score: **2-**

Evidence Based Healthcare Table

Reference: Alsaadi 2008b **Bibliographic Number: 7**

Design	Participants	Exposures	Outcomes
Prospective cohort **Biases/weaknesses:** Cannot definitively assess statistical significance due to too few failures occurring	**Description:** N=238 consecutive patients for implant placement from 2003-2005 Mean age: 56.2yrs (range 18-86yrs) Gender: 77% (187/238) women 720 MkII TiUnite™ implants placed Setting: University, Belgium **Inclusions:** As above **Exclusions:** None stated **Selection Notes:** • At implant placement, a minimal bone height of 7mm had to be available • Implant failure = peri-implant radiolucency, slightest sign of mobility corresponding to PTV ≥ 5, subjective signs of pain or infection that required implant removal • 'early' failure = before & up to abutment connection • the p-value was calculated by either the Fisher or Wilcoxin rank-sum test; to correct for clustering, the generalising estimating equation (GEE) method was used (NB this test needs a sufficient number of failures in each cell of the 2x2 table) • "Because the multivariate & in many cases also univariate GEE analyses are impossible, these results for both systemic disease & medical therapies were given a descriptive character only."	• Smoking habits • Hypertension • Cardiac problems • Gastric problems • Osteoporosis • Hypo- or hyperthyroidism • Hypercholesterolaemia • Asthma • Diabetes type I or II • Crohn's disease • Rheumatoid arthritis • Hysterectomy • Medications (antidepressants, steroids, HRT) • Radiotherapy of concerned area • Jaw bone quality/quantity • Claustrophobia • Implant length & diameter • Implant location • Type of edentulism • Antibiotics • Dehiscence/perforation of jaw bone • Fenestration of implant into sinus/nasal cavity • Immediate placement after tooth extraction • Presence of apical lesion on X-ray • Torque measurement	**Outcome Measures:** Early failure rate (%) Implant success (%; p-value Fischer; GEE) **Results:** Early failure rate: 1.9% (14/720) implants failed 1-6 months after placement Smoking: 98.88% [N] vs. 94.44% [Y] (p<0.001; p<0.001) Gastric problems: 98.38% [N] vs. 92.86% [Y] (p=0.04; p=0.01) Crohn's disease: 98.16% [N] vs. 91.67 [Crohn's] (p=0.21; p=0.02) Type of edentulism: higher failure rate in implants neighbouring teeth (p=0.004; p=NA) Diabetes type I: 98.19% [N] vs. 0% [Y] (p=0.02; p=NA) Radical hysterectomy: 98.74 [N] vs. 90.91 [Y] (p=0.04; p=0.04) Apical lesion detected on X-ray: Significant using GEE (p=0.02) but not significant when using Fisher's exact test (p=0.09) *Implant length or diameter or location, dehiscence or perforation of jaw bone, or fenestration of implant into sinus/nasal cavity, antibiotic use, bone quality/quantity* - no significant effect on early implant failure *Hypertension, ischaemic heart disease, osteoporosis, hypo- or hyperthyroidism, controlled type II diabetes, rheumatoid arthritis, coagulation problems, chemotherapy, claustrophobia, asthma, hypercholesterolaemia, radiotherapy, antidepressant, and steroid medications* – did not significantly increase early implant failures **Methodological Score:** **2-**

Evidence Based Healthcare Table

Reference: Alvim-Pereira 2008 **Bibliographic Number: 44**

<table>
<tr><th>Design</th><th>Participants</th><th>Exposures</th><th>Outcomes</th></tr>
<tr>
<td>Case-control study

Biases/weaknesses:

Significant differences in some baseline characteristics i.e. edentulousness, number implants placed, & PPD

Selection method of ‘controls’ not stated</td>
<td>
Description:
3578 people were treated with NEODENT™ implants from 1996-2006
n=217 people with 1367 implants (1232 ‘healthy’ + 135 ‘lost’ implants)
Setting: University, Brazil
126 (3.5%) people had at least one implant loss

Participant level:

Group S: ‘subjects’
N=80 (63.5%) enrolled as ‘subjects’
Mean age: 52.8yrs
Gender: 60.0% ♀
Ethnicity: 98.8% Caucasian
Smoking: 22.5% smokers

Group C: ‘controls’
N=137 matched by gender, age & smoking status
Mean age: 51.6yrs
Gender: 63.5% ♀
Ethnicity: 95.6% Caucasian
Smoking: 18.2% smokers

Inclusions:
• agreed to participate
• at least 1 implant loss
• no recorded disturbance during surgery or prosthetic procedure

Inclusions:
• at least 1 implant functioning for >6 months
• no implant loss

Exclusions:
• HIV+
• Pregnant or breast feeding
• Orthodontic device in place
• Necrotising ulcerative gingivitis or periodontitis
• Signs of aggressive periodontitis

Implant level:

Group L: ‘lost’
n=135 implants

Group H: ‘healthy’
N=1232 implants

Selection Notes:
</td>
<td>
Patient clinical findings:

• SES status
• General medical condition (systemic disease, diabetes, rheumatoid arthritis, osteoporosis, hypertension, cardiovascular disease, hypothyroidism)
• Medication
• Oral hygiene habits (brushing daily, dental floss daily, mouth wash daily)
• Edentulousness
• Number of teeth/implants
• Vit D receptor polymorphism
• Periodontal status (gingival index, plaque index, calculus index, probing pocket depth, clinical attachment level, mobility)
• Number of clinical appointments

Implant clinical findings:

• position
• primary stability
• dimensions
</td>
<td>
Outcome Measures:

Frequency of particular parameter in each group (%; p-value)

Survival of implant (%; p-value)

Results:

<u>Patient clinical findings</u>:

• More edentulous people in control group (19%) than in subjects (6.3%) [p=0.009]
• More implants placed in subjects (mean=5.55) compared to control group (mean=4.51) [p=0.013]
• Probing pocket dept (PPD) greater in the control group (mean=3.61mm) than the subjects group (mean=3.66mm) [p=0.011]
• SES status, general medical condition, current medication, oral hygiene habits, clinical appointment frequency, number of present teeth, & gingival index, plaque index, calculus index, clinical attachment level, & mobility – no significant difference

<u>Implant clinical findings</u>:

• More lost implants in mandible (63%) than healthy implants (49%) [p=0.003]
• More lost implants in posterior (65%) region than healthy implants (55%) [p=0.037]
• Primary stability greater in H group (69%) than L group (53%) [p=0.001]
• Implant length greater in H group than L group [p=0.001]
• Implant diameter, design, surgical technique, time
</td>
</tr>
</table>

		• design • surgical technique • loading • graft • bone quality/quantity	to load, bone quantity/quality - *no significant difference* Survival: (considering each implant independently) • Only primary stability [p<0.001], surgical technique [p=0.016], & bone quantity [p=0.049] were associated with implant survival over time • Implant location (mandible vs. maxilla, posterior vs. anterior), immediate load, implant design, graft, bone quality – *all not significant*
			Methodological Score: **2-**

Evidence Based Healthcare Table

Reference: Anitua 2008 **Bibliographic Number: 8**

Design	Participants	Exposures	Outcomes
Retrospective cohort **Biases/weaknesses:** Risk of selection bias due to vague inclusion criteria Limited generalisability Financial support for study from manufacturer of BTI® implants & 3 authors are employees of manufacturer	**Description:** 1060 consecutive patients with 5787 Biotechnology Institute (BTI®) implants placed from 2001-2005 in Spain **Group:** N=1060 people with 5787 implants Mean age = 54yrs (range 17-91yrs) Gender: 674 (63.6%) women Drop-outs: none Follow-up: 56.2% of patients and 55% implants followed up for >24mo Mean F/U for all implants: 28.63mo (range 2-59mo) Setting: Biotechnology Institute, Spain Various surgical procedures 221 (20.9%) of participants were smokers (≥1 cigarette per day) **Inclusions:** As above **Exclusions:** None stated **Selection Notes:** "Patient selection was based on the absence of any local or systemic diseases that might contraindicate the treatment" - this appears to be relating to the selection of patients for the surgery in the first instance Before implant placement, periodontal treatment was initiated, if required Implant loss = any implant loss due to biological (failure to or loss of osseointegrate) or biomechanical causes Early loss = before functional loading Late = after functional loading	• age • smoking • implant position • implant diameter/length • staging • special techniques (immediate loading, sinus elevation, crest elevation) • prosthetic items • periodontal disease status (extent and severity) of the failing implant cases	**Outcome Measures:** Overall success/survival rate (%) Relative risk of implant failure* (RR and/or p-value) **Results:** Overall success/survival rate: 99.2% (implant-based), 96.4% (surgery-based) & 96% (patient-based) 0.48% (28 of 5787) implants were lost 16 of 23 patients (69.6%) whose implants failed had chronic/aggressive periodontitis [remaining 5 patients were edentulous] Relative risk of implant failure: Univariate analysis of implant survival: • smoking p=0.013 (implant- & patient-based analysis) • maxilla vs. mandible p=0.031 (implant-based analysis only) • 2-stage surgery p=0.008 (implant-based analysis only) • special techniques vs. none p=0.033 (implant-based analysis only) • gender, age, anterior vs. posterior localisation, implant diameter/length, prostheses type – *all not significantly different* Multivariate analysis (implant-based): • 2-stage RR = 2.28 (95%CI:1.06-4.90) p<0.035 • special techniques RR = 2.5 (95%CI: 0.18-0.85) p<0.04 **Methodological Score:** **2-**

Evidence Based Healthcare Table

Reference: Aykent 2007 **Bibliographic Number: 27**

Design	Participants	Exposures	Outcomes
Retrospective case series **Biases/weaknesses:** Small study sample Statistics not reported No adjustment for confounders Survival/success appear to be secondary outcomes	**Description:** Consecutive people (n=34) who had implants placed over a 12 year period (1990-2002) at the Selcuk University Faculty of Dentistry in Konya, Turkey. **Group:** 106 implants (54 Calcitek and 52 Straumann) placed in n=34 people (20 women; 14 men) with mean age of 44.5yrs (range 19-70yrs). 42 implants (20 Calcitek and 22 Straumann) placed in maxilla and 64 (34 Calcitek and 30 Straumann) placed in the mandible After 3-6mths, abutments were placed Prostheses: 19 FPDs, 19 single crowns and 12 implant-supported overdentures First examination after prosthesis placement provided baseline measurements. Subsequent examinations occurred yearly. **Inclusions:** As above **Exclusions:** None stated **Selection Notes:** Factors examined: • modified sulcus bleeding index (mSBI) • modified plaque index (mPI) • modified gingival index (mGI) • keratinised mucosa index (KMI) • probing depths (PDs) measured at 6 points Data collected: • sex and age • date of implant placement • implant manufacturer and type • number and location of implants • date of prosthesis placement • type of prosthesis • prosthesis complications • smoking habits (>10 cigs per day = recorded as smokers)	• Location (maxilla or mandible) • Smoking status • Prosthesis type (overdenture or FPD) • Implant make (Straumann or Calcitek)	**Outcome Measures:** Cumulative survival rates (%) Cumulative success rates (%) **Results:** <u>Overall:</u> Cumulative survival rate at 12yrs was 95.2% Cumulative success rate at 12yrs was 90.2% <u>Types of implant:</u> Hollow-screw implant cumulative success rate 100% Solid-screw implant cumulative success rate 94.5% Hollow-cylinder implant cumulative success rate 83.9% <u>Location:</u> Mandibular implant cumulative success rate 92.2% Maxillary implant cumulative success rate 87.0%* <u>Smoking status:</u> Cumulative success rate of implants in smokers 75.8% Cumulative success rate of implants in non-smokers 97.7%* <u>Implant make:</u> Cumulative success rate of Straumann implants 94.1% Cumulative success rate of Calcitek implants 79.5% <u>Type of prosthesis:</u> Cumulative success rate of implants supporting overdentures 71.5% Cumulative success rate of implants supporting FDPs 98.0%* *reported as significantly different **Methodological Score:** 3

Evidence Based Healthcare Table

Reference: Degidi 2006 **Bibliographic Number: 9**

Design	Participants	Exposure	Outcomes
Case series **Biases/weaknesses:**	**Description:** n=111 consecutively enrolled subjects who had a immediate non-functional single implant restoration Setting: not reported but seems to be at a University (Italy) Non-blinded evaluations by 3 independent examiners Various implant surfaces & implant diameters (chosen according to shape of alveolar defect and bone quality) & various brands of implants Final restorations cemented and completed approximately 32 weeks after implant insertion Participants were all part of a strict hygiene recall and were re-evaluated after 1, 2, 3, 4, & 5yrs	• Healed or post-extraction site • Bone quality (D1-4) • Implants location (mandible vs. maxilla) • Implant length, diameter, & surface	**Outcome Measures:** Implant success/survival (%)
	Group: No. in Group: n=111 Mean Age: 40yrs (15-83yrs) Gender: 65 (58.6%) women Sites: 23 central incisors, 40 lateral incisors, 22 cuspids & 26 pre-molars 67 (60%) were in immediate post-extraction sites		**Results:** Overall survival rate = 95.5% Cumulative success rate = 97.2% at 5yrs Significant difference ($p<0.05$) in survival at 5yrs between: 1. Healed (100%) vs. post-extraction site (92.5%) 2. Bone quality D1 (100%) vs. D4 (95.5%) No significant difference in 5yr survival between: 1. Implants placed in the mandible (100%) vs. the maxilla (94.6%) 2. Implants <13mm long (96.97%) vs. those >13mm long (94.87%) 3. Implants <4.5mm in diameter (97.26%) vs. those >4.5mm in diameter (92.11%) 4. Different implant surfaces
	Inclusions: • bone site that would allow placement of an implant (dimensions given) & no need for bone augmentation • controlled oral hygiene with natural teeth on either side of implant & no teeth decay or active periodontal disease • informed consent **Exclusions:** • uncontrolled periodontal disease • adjacent teeth exceed class I mobility • bruxism or other parafunctional habits • unstable posterior occlusion • smoking >20cigs/day • general health or medication that may affect osseointegration		
	Selection Notes: Implant success = absence of persistent pain or dysesthesia, peri-implant infection with suppuration, mobility, and persistent peri-implant bone resorption (parameters given)		**Methodological Score:** 3

Evidence Based Healthcare Table

Reference: de Luca 2006 **Bibliographic Number: 18**

Design Description	Participants	Exposure	Outcomes
Retrospective cohort study **Biases/weaknesses:** Statistically significant higher rate of failure observed among non-respondents (p=0.001) may bias results Exclusion/inclusion criteria not reported	**Description:** n=464 consecutively treated patients who had 1852 dental implants (Brånemark) placed between 1979 and 1999 (20yrs) at the Implant Prosthodontic Unit at the University of Toronto • initial consultation: baseline demographics, medical and dental history and clinical and X-ray examination • 2 stage surgery • 14 surgeons (majority placed by 3) over 20 yrs • completely edentulous had fixed or overdenture prostheses fitted • partially edentulous had single or multiunit fixed prostheses fitted • regular recall appointments • questionnaire was sent to all participants to identify past or current tobacco use and also #cigs per day smoked and years smoked (cy = cigarette years = cigs/day x years smoked) NB: these patients were part of the study populations from previous prospective studies (with inclusion and exclusion criteria described elsewhere)	• Smoking status* • Age • Gender • Location of implant • Prosthesis • Opposing dentition	**Outcome Measures:** Overall survival (%) Risk of implant failure (RR, p-value)
	Group: N=464 people with 1852 implants (1106 in women; 746 in men) Age: mean = 49.3yrs (range: 15-84yrs) [mean women=49.7yrs; men 48.9yrs] Gender: 283 women; 181 men Average number of implants: 4.0 (women 3.91; men 4.12) No significant diff in mean ages of men/women or number of implants placed per patient between NS1, S1, NS2, and S2* groups Post-insertion mean F/U = 59.8mths (1-230mnths) 584 various prostheses were delivered in total Questionnaire response rate = 84% (4% [17] died; 12% [58] not able to contact) Smoking status recorded in 389 patients (84%) with 1539 implants At time of implant placement 285 (1045 implants) non-smokers and 104 (494 implants) smokers Smoking Hx: 192 (860 implants) > 25cy and 197 (679 implants) ≤ 25cy		**Results:** Overall crude survival rate = 92.28% for duration of study i.e. 143 (7.72%) of 1852 implants failed <u>Implant failure</u> (multivariate analysis): Early failures: 1. smoking at time of implant placement vs. non-smoking RR = 1.69 p=0.05 2. longer vs. shorter implants RR = 0.76 p=0.001 3. mandible vs. maxilla RR = 0.56 p=0.030 Late failures: (based on 1774 remaining implants) 4. positive smoking history RR = 1.91 p=0.050 5. short vs. long implant length RR = 1.16 p=0.030 6. maxilla vs. mandible RR = 2.38 p=0.004
	Inclusions: • "described elsewhere" **Exclusions:** • "described elsewhere"		

	Selection Notes: • early failures = implants removed prior to placement of prostheses • late failure = removed after prosthetic rehabilitation • failure = removed because of clinical mobility or evidence of peri-implant radiolucency and/or persistent pain, discomfort or infection that was attributable to the implant *Smoking status: Group A – to assess the effect of smoking at the time of implant placement ➢ NS1 – never or stopped ≥ 1 week before implant placed ➢ S1 – smokers at placement and continued till stage 2 surgery Group B – to assess the effect of a positive smoking history on ➢ NS2 – never or smoked ≤ 25cy until stage 2 surgery ➢ S2 – > 25cy smoking history		**Methodological Score:** **2-**

Evidence Based Healthcare Table

Reference: Elkhoury 2005 **Bibliographic Number: 52**

<table>
<tr><th>Design</th><th>Participants</th><th>Exposure</th><th>Outcomes</th></tr>
<tr>
<td rowspan="5">Case-control study

Biases/weaknesses:
Small sample

Definition of failure stricter than other studies

Selection bias possible</td>
<td colspan="2">Description:
39 people with 39 single tooth titanium plasma-sprayed cylindrical implants
Mean age = 49.2yrs
Gender: 22 ♀; 17 ♂
21 implants in posterior sites; 18 placed in anterior sites
Implant type = 3i (Implant Innovations) implants
21/39 implants at posterior site; 18/39 in anterior site
25 in maxilla; 14 in mandible
No implant required soft tissue/bone grafting at time of placement or during follow-up period
All implants stable and functioning at 5yr examination</td>
<td rowspan="5">Age
Gender
Location (anterior vs. posterior; mandible vs. maxilla)
Bone quality
Probing depth
Attachment level
Gingival index
Bone level
Implant length</td>
<td rowspan="2">Outcome Measures:
Age (years; p-value)
Gender (♀ or♂; p-value)
Location (anterior vs. posterior; mandible vs. maxilla; p-value)
Bone quality (1-4; p-value)
Probing depth (mm; p-value)
Attachment level (mm; p-value)
Gingival index (0-3; p-value)
Bone level (mm; p-value)
Implant length (mm; p-value)</td>
</tr>
<tr>
<td>Group 1: ‘failures’
No. in Group: n=20
Mean Age: 51yrs (range: 25-65)
Gender: 45% ♀</td>
<td>Group 2: ‘successes’
No. in Group: n=19
Mean Age: 47yrs (range: 36-62)
Gender: 68% ♀</td>
</tr>
<tr>
<td colspan="2">Inclusions:
≥18 years old
Edentulousness in maxilla or mandible
Good general health
Enough bone for implant to be placed
No oral, dental or soft tissue pathologies
Exclusions:
Uncontrolled metabolic disease, immunocompromise, uncompensated systemic disease, alcohol/drug abuse, debilitating TMJ disease, or mental illness
Smoking
History of irradiation or previous implant at surgical site
Pregnant, or prisoner
<5mm bone width on physical examination, or <10mm bone height on X-ray examination</td>
<td rowspan="2">Results:
Bone quality (mean):
2.90 [failed] vs. 1.79 [successful] p<0.001
Age, gender, location:
no statistically significant differences</td>
</tr>
<tr>
<td colspan="2">Selection Notes:
“failures” = those implants with an attachment loss rate (ALR) ≥0.25mm after first year of function
“success” = those implants with an attachment loss rate (ALR) <0.25mm after first year of function</td>
</tr>
<tr>
<td colspan="3"></td>
<td>Methodological Score:
2-</td>
</tr>
</table>

Evidence Based Healthcare Table

Reference: Esposito 2008 **Bibliographic Number: 2**

Design Description	Participants	Intervention	Outcomes
Systematic review **Biases/weaknesses:** These findings are based on few trials including few patients, sometimes having short follow-up and often judged to be at high risk of bias	**Description:** 40 publications identified by search N=17 RCTs included with a total of 455 participants Studies included: Dahlin 1991, Carpio 2000, Wannfors 2000, Hallman 2002, Jung 2003, Stellingsma 2003, Chiapasco 2004, Cornelini 2004, Chen 2005a, Chen 2005b, Raghoebar 2005, Szabo 2005, Raghoebar 2006, Chen 2007, Chiapasco 2007, Meijndert 2007, Merli 2007 Follow-up: ½-3yrs Search strategy specific 3 databases & handsearched 15 relevant journals Various bone augmentation techniques & various comparators employed Quality assessment based on allocation concealment, blinding of outcome assessors, & completeness of follow-up No meta-analysis due to heterogeneity of interventions Publication bias not assessed	• Bone augmentation	**Outcome Measures:** Risk of implant failure (OR: 95%CI) Risk of prosthetic failure (OR: 95%CI) Risk of major complication at implant site (OR: 95%CI)
	Inclusions: • RCTs including split-mouth & preference RCTs* • Patients with missing teeth who may require alveolar bone augmentation prior to or during dental implant placement procedures • Any bone augmentation technique, active agent (such as bone morphogenetic proteins, platelet rich plasma) or biomaterials used in relation with osseointegrated, root-formed dental implants. • Reported at least at the endpoint of the abutment connection procedure. • Outcome measures included: o Prosthesis failure o Implant failure** o Complications o Patient satisfaction o Treatment costs. **Exclusions:** • none stated		**Results:** <u>Risk of implant failure:</u> (2 studies) • OR=5.00 (95%CI: 0.22-115.05) • OR=14.79 (95%CI: 0.76-289.43) <u>Risk of prosthetic failure:</u> (2 studies) • OR=5.00 (95%CI: 0.22-115.05) • OR=3.16 (95%CI: 0.12-82.64) <u>Risk of major complication at implant site:</u> (2 studies) • OR=5.00 (95%CI: 0.22-115.05) • OR=3.86 (95%CI: 0.67-22.11) NB: both studies assessed as being at high risk of bias

	Selection Notes: *Preference RCTs are those trials in which patients not having a preference for the tested interventions are randomised, whereas those patients who have a definitive preference are allocated to their preferred intervention group. ** Implant failure = implant mobility and removal of stable implants dictated by progressive marginal bone loss or infection		**Methodological Score:** **1+**

Evidence Based Healthcare Table

Reference: Evian 2004 **Bibliographic Number: 45**

<table>
<tr><th>Design</th><th>Participants</th><th>Exposure</th><th>Outcomes</th></tr>
<tr><td rowspan="6">Retrospective cohort

Biases/weaknesses:
High risk of bias: vague inclusion/exclusion criteria; not all important confounders considered</td><td colspan="2">Description:
149 consecutive patients treated at one private periodontal practice by a single clinician
Investigators (other than the treating clinician) completed data collection
Endodontic therapy was performed prior to implant placement if a periapical lesion was present
Periodontal treatment was performed prior to or in conjunction with implant placement
Variety of implant surfaces, length, diameter, and placement timing</td><td rowspan="6">• Periodontal disease</td><td>Outcome Measures:
Survival rate (%)
Risk of implant failure (%, p-value)</td></tr>
<tr><td>Group 1: ‘healthy’
No. in Group: n=72
Mean Age: not reported
Gender: not reported
Mean follow-up: 934 days (range 35-4030 days)</td><td>Group 2: ‘periodontal disease’
No. in Group: n=77
Mean Age: not reported
Gender: not reported
Mean follow-up: 722 days (range 18-3548 days)</td><td rowspan="3">Results:
Unadjusted overall survival rate: 85.2%

Failure rate in periodontal disease group: 21% (16/77)
Failure rate in healthy group: 8% (6/72)

RR = 2.49 (95%CI: 1.03-6.02)</td></tr>
<tr><td colspan="2">Inclusions:
• Only patients with 1 implant in place
• Implant needed to be exposed and loaded for at least 1 year
• ‘periodontal disease’ group = ≥1 tooth with probing depth ≥5mm and associated with X-ray signs of bone loss or people who originally lost their teeth reason to periodontitis
• ‘healthy’ group = no history or current manifestations of periodontal disease</td></tr>
<tr><td colspan="2">Exclusions:
• People with multiple implants in place
• People with contraindicated disease e.g. uncontrolled endocrine disorders
NB people with diabetes were treated with implants only if their physicians certified that their disease was under control</td></tr>
<tr><td colspan="2">Selection Notes:
Survival of implant = implant continued to support load-bearing restoration and free from irresolvable clinical complaints e.g. peri-implant radiolucency, chronic pain, implant mobility, progressive bone loss</td><td>Methodological Score:
2-</td></tr>
<tr><td colspan="2">Comments:</td></tr>
</table>

Evidence Based Healthcare Table

Reference: Gentile 2005 **Bibliographic Number: 53**

Design

Retrospective cohort

Biases/weaknesses:
Small number of participants

Participants

Description:
People with at least 1 Bicon 6x5.7mm implant placed between 1997 and 2002 at Implant Dentistry Centre at Faulkner Hospital, Boston
n=35 people with 172 implants placed
45 (26%) of implants were 6x5.7mm
Gender: 53.3% (20) men
Mean age: 59.2 ± 12.0yrs
88.5% "healthy"
43.6% in posterior mandible
28.5% placed in proximity to 1 tooth & 1 implant
47.5% placed in type IV bone

Inclusions:
- charts available for review
- data collected for all implants placed in this cohort

Exclusions:
- none stated

Selection Notes:
Failure = removal of implant

* only looked at 1yr survival because short F/U for most 6x5.6mm implants (24.5mo vs. 31.8mo for non 6x5.7mm implants)

Exposures

- Dimensions of implants
- Age & gender
- Health status
- Location, proximity to teeth/implant, bone quality
- Implant length/diameter/coating
- Single crown/fpd/removable prosthesis/overdenture
- Peri-operative antibiotics
- Reconstructive procedures

Outcomes

Outcome Measures:
1 year survival rate (%)
Risk of failure (HR; 95%CI)

Results:
Survival analysis:
6x5.7mm implants
- 1-yr survival rate* = 92.2% (95%CI: 83.6-100%)

Non-6x5.7mm implants
- 1-yr survival rate* = 95.2% (95%CI: 91.1-99.3%)

p=0.78

Multivariate analysis:
Size (6x5.7mm vs. non-6x5.7mm)
- HR=1.0 (95%CI: 0.3-4.3) p=0.95

Age at implant placement
- HR=1.0 (95%CI: 0.9-1.0) p=0.14

Female gender
- HR=1.1 (95%CI: 0.3-4.3) p=0.92

"Medically compromised"
- HR=0.4 (95%CI: 0.0-4.2) p=0.46

2-stage surgery
- HR=0.2 (95%CI: 0.04-1.03) p=0.055

Bone graft augmentation
- HR=2.6 (95%CI: 0.6-12.1) p=0.23

Methodological Score:
2-

Evidence Based Healthcare Table

Reference: Graziani 2004 **Bibliographic Number: 55**

<table>
<tr><th>Design Description</th><th>Participants</th><th>Intervention</th><th>Outcomes</th></tr>
<tr>
<td rowspan="2">Systematic review

Biases/weaknesses:
Limited number of studies

Limited quality assessment

Posterior maxillary implants only</td>
<td>Description:
579 publications identified by search
N=6 studies included with a total of 394 participants with 989 implants
Studies included: Bouchman 1999, Johansson 1999, Ellegaard 1997, Lozada 1993, Smedberg 2001, & Tawil 2001
Search strategy: broad strategy
Databases: CENTRAL, MEDLINE & EMBASE up to 2004
Quality assessment: done (based on blinding of examiners and completeness of follow-up)
All studies employed a simultaneous grafting and implant placement procedure
No meta-analysis due to heterogeneity
Publication bias: not reported</td>
<td rowspan="2">• Bone augmentation procedure in maxilla</td>
<td>Outcome Measures:
Survival (%)
Complications (number)</td>
</tr>
<tr>
<td>Inclusions:
• controlled trial
• comparing implant placement in the non-augmented posterior maxilla with the augmented maxillary areas
• groups were of at least 20 patients
• number of implants and duration of follow-up reported
• outcomes: implant survival, changes in X-ray peri-implant bone height, and number of complications
NB any graft & implant type & sinus augmentation technique
Exclusions:
None stated

Selection Notes:</td>
<td>Results:
<u>Survival:</u>
Patient-based (2 studies)
• 36-100% for augmented sites
• 73-100% for non-augmented sites
• follow-up period 3-5yrs
Implant-based (6 studies)
• 75-100% for both augmented and non-augmented sites
• follow-up period 8-72mo

<u>Complications</u>: (2 studies)
• one reported no complications
• the other reported 2 fistulae in the control group; 4 fistulae, 2 sinusitis, 1 dehiscence & 1 adverse load in test group

<table>
<tr><th>Study</th><th>Control group</th><th>Test group</th></tr>
<tr><td>Bouchman 1999</td><td>37/37 (100%)†</td><td>50/50 (100%)†</td></tr>
<tr><td>Ellegaard 1997</td><td>24/24 (100%)*
13/14 (93%)§</td><td>25/26 (96%)*
10/12 (83%)§</td></tr>
<tr><td>Lozada 1993</td><td>105/140 (75%)</td><td>120/133 (90%)</td></tr>
<tr><td>Johanson 1999</td><td>27/37 (73%)†</td><td>10/28 (36%)†</td></tr>
<tr><td>Smedberg 2001</td><td>192/206 (93%)</td><td>99/131 (75%)</td></tr>
<tr><td>Tawil 2001</td><td>33/41 (80%)</td><td>35/35 (100%)</td></tr>
</table>
*Astra implants
§ITI implants
†patient-based analysis (all the rest are implant-based analysis)

Methodological Score:
1+</td>
</tr>
</table>

Evidence Based Healthcare Table

Reference: Herrmann 2005 **Bibliographic Number: 51**

Design

Analysis of data from 4 prospective cohort studies

Biases/weaknesses:
High risk of confounding

Participants

Description:
Data from 4 prospective multicentre studies reporting on Brånemark implants
Studies included: Henry 1996, Lekholm 1994, Jemt 1996, Freiberg 1997
Each study had different patient groups e.g. single tooth loss (Henry 1996), partial edentulism (Lekholm 1994), edentulous with overdentures (Jemt 1996), and edentulous with fixed prostheses (Freiberg 1997)
All followed similar protocols including consecutive patient inclusion
Condition of implants evaluated at 5yrs (from prosthetic loading) - measured success, marginal bone loss, & complications.
Results included all events from implant placement to final 5yr check-up
1, 3, & 5yr results already published

Population:

- 487 participants with 1738 implants
- 55.6% women
- mean age 51.3yrs
- 531 restorations
- 16.2% (79/487) drop-outs*

All participants reported as "healthy"

*not seen at final check-up

Implant level:

- 1738 source population
- 323 (18.6%) not examined ['drop-outs']
- 1415 sample pop
- 110 (7.8%) failed
- 1305 successful

One implant was randomly selected [method not described] from each participant, therefore final analysis based on:

- 487 implants
- 80 (16.4%) withdrawn
- 36 (8.8%) failed
- 371 successful

Inclusions:

- as above

Exclusions:

- none stated

Selection Notes:
Success = absence of implant mobility + marginal bone resorption not greater than "limits set by Albrektsson and associates"

Exposure

- Age
- Gender
- Maxilla or mandible
- Clinic responsible
- Jaw shape
- Jawbone quality
- Implant length
- Number of implants per restoration
- Treatment protocols

Jawbone quality	Failures (%)
1	11.1
2	4.5
3	5.7
4	24.5
Total	**7.4**

Outcomes

Outcome Measures:
Cumulative success rate (%)
Implant failures (significant or not)

Results:
Cumulative success rate after 5yrs = 92.4%

Implant failures:

- Gender, age, clinic & number of implants supporting the prosthesis - *not significantly different*
- Maxilla vs. mandible; jawbone quality/shape & combinations; implant lengths; treatment protocols - *all significantly different*
  i.e. greater risk of failure when implant placed in maxilla, type 4 bone, jaw shape D & E, & bone 'combination IV'*.

*combination of type 4 bone and jaw shapes D & E

Methodological Score:
2-

Evidence Based Healthcare Table

Reference: Hinode 2006 **Bibliographic Number: 14**

Design Description	Participants	Exposure	Outcomes
Systematic review **Biases/weaknesses:** No quality appraisal of individual studies No weighting of individual studies in meta-analysis Significant heterogeneity Combined results in meta-analysis from different study designs	**Description:** 175 publications identified by search N=19 met inclusion criteria (12 case-control; 7 cohort) Studies included: Bain 1993, De Bruyn 1994, De Bruyn 1999, Geurs 2001, Gorman 1994, Jones 1999, Kan 2002, Karoussis 2003, Keller 1999, Kuroyama 2001, Lambert 2000, Leonhardt 2003, Minsk 1996, Schwartz-Arad 2002, Shiratori 2003, Wallace 2000, Wang 1996, Widmark 2001, Yamada 1997. NB Keller 1999 & Minsk 1996 already included in previous dental implant review Studies (n=7) used for influence of location: Bain 1993, De Bruyn 1999, Lambert 2000, Minsk 1996, Shiratori 2003, Wallace 2000, Yamada 1997. Broad search strategy of 2 electronic databases (MEDLINE 1993-2004 & 'Japana Centra Revuo Medicina' 1993-2004 and 2 journals ('Dentistry in Japan' 1993-2004 & 'Clinical Research in Dentistry' 2004). Heterogeneity tested and compensated for. Publication bias considered and tested for. Sensitivity analysis of cohort vs. case-control studies, studies published before 2000 vs. after 2000, studies with <200 case vs. 200 cases or more, & failure rate <10% vs. 10% or more	• Smoking • Location of implant (mandible vs. maxilla)	**Outcome Measures:** Risk of failure (pooled OR) **Results:** <u>Implant failure in smokers compared to non-smokers:</u> • OR (pooled) = 2.17 (95%CI: 1.67-2.83) [random effects model] • range of ORs = 0.64 – 23.1 <u>Implant failure by location in smokers compared with non-smokers:</u> • OR (maxilla) = 2.06 (1.61-2.65) [fixed model] • OR (mandible) = 1.32 (0.72-2.4) [random model]
	Inclusions: • case-control or cohort study design • smoking examined as a risk factor for implant failure • "failure" = removed (for any reason) and showed progressive bone loss (assessed by X-ray) **Exclusions:** • case reports, case series or reviews		
	Selection Notes: • Search may not be wide enough (only two electronic databases & 2 journals searched)		**Methodological Score:** **2-**

Evidence Based Healthcare Table

Reference: Holahan 2008 **Bibliographic Number: 10**

Design

Retrospective cohort

Biases/weaknesses:
High risk of confounding

Participants

Description:
All women ≥50yrs who had a dental implant placed between 1983-2004 at the Mayo Clinic, Minnesota.
N=192 postmenopausal women with 646 implants
Mean age = 63.4yrs (range 50.3-84.9yrs)
24/192 (12.5%) were smokers
Mean length of F/U (not failed) = 5.4yrs (range 11days - 2yrs)
39 implants were removed (2 were associated with purulence and so were censored from results; of the 37 left, 35 failed due to failure of osseointegration or loss of osseointegration and 2 failed due to implant fracture)
Setting: University, USA

Group1: "Non-OP"	**Group2: Osteopenia**	**Group3: Osteoporosis**
No. in Group: 94	No. in Group: 57	No. in Group: 41
Mean Age: 61.8yrs (range 50.4-82.9)	Mean Age: 64.0yrs (range 50.3-84.9)	Mean Age: 66.0yrs (range 52.0-84.9)
Smokers: 14 (14.9%)	Smokers: 6 (10.5%)	Smokers: 4 (7.8%)
Total implants: 306	Total implants: 197	Total implants: 143
Number failed: 17	Number failed: 10	Number failed: 10

Inclusions:
- as above
- a bone mineral density (BMD) T-score available within 3yrs of implant placement

Exclusions:
- denied permission to be contacted for research purposes
- implants that had failed due to infection or internal manufacturing defect

Selection Notes:
Implant failure = any implant that had to be removed due to any reason other than infection or internal manufacturing defect (if purulence was noted at the time of implant removal then the failure was considered infection-related)

Exposures

- Osteoporosis
- Osteopenia
- Arch location
- Smoking status

Outcomes

Outcome Measures:
Survival (%)
Risk of failure (HR*; 95%CI; p-value)
*hazard ratio

Results:
Survival:
Overall
- 5yr survival rate = 93.8%
- 10yr survival rate = 92.5%

Smokers
- 5yr survival rate = 87.3%
- 10yr survival rate = 87.3%

Non-smokers
- 5yr survival rate = 94.6%
- 10yr survival rate = 93.1%

Hazard ratio:
Osteopenia
- HR = 0.98 (95%CI: 0.50-2.60), p=0.76

Osteoporosis
- HR = 1.14 (95%CI: 0.40-2.42), p=0.97
- HR/unit decrease = 1.12 (95%CI: 0.93-1.35), p=0.25

Arch location
- No significant association

Smoking
- HR = 2.6 (95%CI: 1.20-5.63), p=0.016

Methodological Score:
2-

Evidence Based Healthcare Table

Reference: Karoussis 2007 **Bibliographic Number: 46**

Design Description	Participants	Exposures	Outcomes
Systematic review **Biases/weaknesses:** No methodological assessment Risk of publication bias Only 1/3 of the studies included a control group Studies have not clearly defined 'periodontal status'	**Description:** Search identified 2987 publications N=15 studies included with a total of 1061 people with 3432 implants Studies included: Baelum 2004, Brocard 2000, Buchmann 1999, Ellegard 1997a & b, Ellegard 2006, Ericsson 1986, Karoussis 2003, Leonhardt 2002, Mengel 2001, Mengel 2005a & b, Rosenberg 2004, Sbordone 1999, Wennstrom 2004 Search: Pubmed (MEDLINE) & Cochrane Oral Health databases. Search terms given. Also, 15 relevant journals were handsearched as well as the reference lists of identified publications. Titles/abstracts screened independently by 3 reviewers. Methodological assessment: not reported Heterogeneity/publication bias: not reported Results presented narratively due to "considerable discrepancies among the studies" **Inclusions:** English language, prospective clinical studies only, placement of dental implants in periodontally compromised partially edentulous people, periodontal therapy completed before placement of implant(s), absence of active inflammation at time of placement, F/U period >1yr, reporting of implant success/survival **Exclusions:** Reporting mixed data e.g. both partially and fully edentulous people included **Selection Notes:** Implant 'success' = PPD ≤5mm, no bleeding on palpation, & bone loss <0.2mm annually. 'Short-term' = <5yrs observation period 'Long-term' = ≥5yrs observation period *CAL = clinical attachment level PPD = probing pocket depth MPBL = mean peri-implant bone loss †MBL = marginal bone loss	• History of chronic or aggressive periodontitis	**Outcome Measures:** Survival (%) **Results:** <u>Chronic periodontitis:</u> • The majority of studies tend to indicate that short-term & long-term survival rates in partially edentulous people with a history of chronic periodontitis are comparable to those reported for periodontically healthy individuals. NB an uninterrupted strict individualised maintenance care programme was followed after implant placement. • The short-term stability of CAL*, PPD, & MPBL around implants in this population group has been demonstrated. However, in the long-term, PPD tends to increase around the implants in people with a history of chronic periodontitis & there may be an increased incidence of peri-implantitis. • Smoking may exert a negative influence on PPD, MBL† & implant survival. <u>Aggressive periodontitis:</u> • The short-term survival rates for people treated for aggressive periodontitis may be comparable to people without a history of aggressive periodontitis, however there is limited data on their long-term survival. • No differences in PPD between people treated for aggressive periodontitis and periodontally healthy people were found, however CAL seems to be greater in aggressive periodontitis patients. • In the short-term, no statistically significant differences in peri-implant bone loss may be detected between people treated for aggressive periodontitis and periodontally healthy people. **Methodological Score:** **2-**

Evidence Based Healthcare Table

Reference: Kinsel 2007 **Bibliographic Number: 30**

Design	Participants	Exposure	Outcomes
Retrospective cohort analysis of case series data **Biases/weaknesses:** Retrospective study. Small sample. Not all prognostic factors recorded e.g. periodontitis	**Description:** N=43 consecutive patients who had had 344 dental implants placed in 56 edentulous arches between 1996-2004 at a single private practice by one dentist and one surgeon in the USA. No. in Group: 43 Mean Age: 58 years (range 35-80yrs) Gender: 31 (72%) women, 12 (28%) men Implants: Straumann titanium single-stage, solid-threaded (131 titanium plasma-sprayed & 213 sandblasted, large-grit, acid-etched surfaces) Smokers: 12 (27.9%), smoking ≥20 cigs per day Combined maxillary and mandibular edentulism: 13 Single edentulous arches opposing full or partial natural dentition: 30 Range of lengths and diameters of implants The definitive metal-ceramic fixed prostheses consisted of 10-12 dental units supported by 4-10 implants [60.7% of patients had 6 implants] 16 patients had bone grafts Drop-outs: none reported Follow-up: 2-10yrs Setting: Private dental practice **Inclusions:** As above. **Exclusions:** None stated **Selection Notes:** Failure = if solid abutments did not achieve torque of 35 Ncm when tightened Immediate loading of edentulous arches with fixed prostheses	Patient-specific factors: • Age (≤59yrs or ≥60yrs), • Gender, • Smoking status, • Presence of grafted bone, and • Posterior location (maxilla only, mandible only or both arches) Implant-specific factors: • Surface treatment, • Anterior or posterior location in dental arch, • Diameter, • Length, • Jaw (maxilla or mandible) and • Surgical technique	**Outcome Measures:** Overall survival (%) % failure (p value) **Results:** Overall survival: 95.3% 16/344 implants failed (4.7%) in 10 patients. Univariate analysis: Patient-specific factors: • none statistically significant Implant-specific factors: significantly higher rates of failure for: • implants placed in posterior quadrant p=0.001 • shorter implants p<0.001 • larger diameter implants p<0.02 • SLA implants p<0.03 Multivariate analysis: Significantly higher rates of failure for shorter implants p<0.001 **Methodological Score:** **3**

Evidence Based Healthcare Table

Reference: Klokkevold 2007 **Bibliographic Number: 11**

Design	Participants	Exposure	Outcomes
Systematic review **Biases/weaknesses:** No assessment of heterogeneity or publication bias Quality assessment only based on study design Heterogeneous definition of "success" Combining survival at different follow-up times may introduce bias English only No distinction between 'early' & 'late' implant loss	**Description:** >2500 articles identified by search + 48 from handsearch 122 articles selected for full-article review N = 34 studies with 1150 participants with 10904 implants met inclusion criteria (18 for smoking, 4 for diabetes, & 13 for periodontitis) NB one study reported outcomes for both smoking and periodontitis <u>Studies included in review:</u> • Smoking: Bain 1993, Bain 1996, De Bruyn 1994, Geurs 2001, Gruder 1999, Jones 1999, Kan 2002, Karoussis 2003, Keller 1999, Lambert 2000, Minsk 1996, Minsk 1998, Morris 1998, Wallace 2000, Wang 1996, Watson 1998, Widmark 2001, & Zitzman 1999. • Diabetes: Morris 2000, Olson 2000, Peled 2003, & Shernoff 1994. • Periodontitis: Brocard 2000, Baelum 2004, Ellegaard 1997, Evian 2004, Hardt 2002, Karoussis 2003, Leonhardt 1993, Leonhardt 2002, Mengel 2001, Mengel 2005, Nevins 1995, Wennstrom 2004, & Yi 2001. Low-specificity search of MEDLINE, EMBASE & Cochrane Collaboration to 2005 (start date not reported) Search strategy/terms not reported Two reviewers evaluated each title & abstract Process for resolving disagreements Quality assessment was based on the study design and ranked as: • No studies assessed as "best" (RCT, double blind), • 3 studies assessed as "better" (prospective clinical trial with concurrent controls), • No studies assessed as "good" (prospective clinical trial with historical controls), • 13 studies assessed as "average" (prospective case studies), • 15 studies assessed as "fair" (retrospective case studies), or • 3 studies assessed as "unknown" (none of the above). Heterogeneity & publication bias: not addressed	• Smoking • Diabetes • Periodontitis (history of treated periodontitis)	**Outcome Measures:** Pooled estimate of survival rate (%; 95% CI) Pooled estimate of success rate (%; 95% CI) Pooled estimate of difference in survival/success rate (%; 95%CI; p-value) **Results:** <u>Smoking:</u> *Survival (14 studies)* • Smokers = 89.7% (95%CI: 87-92.4%) • Non-smokers = 93.3% (95%CI: 91-95.6%) Difference in survival = 2.68% (95%CI: 1.1-4.26%) p=0.0009 *Survival in loose trabecular bone (5 studies)* • Smokers = 86.1% (95%CI: 81.8-90.4%) • Non-smokers = 92.4% (95%CI: 87.6-97.2%) Difference in survival = 7.43% (95%CI: 3.16-11.69%) p=0.0006 *Survival in all anatomical locations (9 studies)* • Smokers = 91.3% (95%CI: 88-94.6%) • Non-smokers = 93.7% (95%CI: 91-96.4%) Difference in survival = 2.01% (95%CI: 0.49-3.52%) p=0.0093 *Success (7 studies)* • Smokers = 77% (95%CI: 66.1-87.9%) • Non-smokers = 91% (95%CI: 86.6-95.4%) Difference in success = 11.28% (95%CI: 3.41-19.15%) p=0.005

	Inclusions: 1. People of any age, sex or race who have had root-form dental implants inserted 2. Provided information about either a. smoking status b. diabetes status, or c. periodontitis status of patients 3. Follow-up data of, at least 1 year 4. Published in English **Exclusions:** 1. Animal/laboratory/in vitro studies 2. Case report study or study with < 10 patients 3. Non-root-form implants 4. Less than 1 yr follow-up data 5. Patients had medically compromising conditions or other risk factors e.g. radiation therapy, metabolic bone disease, immune compromise 6. Treatment included substantial bone augmentation (only applies to diabetes and periodontitis)		*Success in loose trabecular bone (2 studies)* • Smokers = 72.1% (95%CI: 54.1-90.1%) • Non-smokers = 83.2% (95%CI: 78.2-88.2%) Difference in survival = 9.51% (95%CI: -8.64 to 27.67%) p=0.3045 *Success in all anatomical locations (5 studies)* • Smokers = 78.4% (95%CI: 65.1-90.9%) • Non-smokers = 93.9% (95%CI: 90.3-97.5%) Difference in survival = 11.76% (95%CI: 2.7-20.82%) p=0.0109 <u>Diabetes:</u> Type II only *Survival (4 studies)* • Diabetics = 91.7% (95%CI: 89.1-94.3%) • Non-diabetics = 93.2% (95%CI: 92.2-94.1%) Difference in survival not possible. Implant success not reported in any studies. <u>Periodontitis:</u> (13 studies) *Survival* • History of treated periodontitis (10 studies) = 95% (95%CI: 91.8-98.2%) • No history of treated periodontitis (3 studies) = 97.1% (95%CI: 94.8-99.4%) Difference in survival (3 studies) = -3.14% (95%CI: -6.97 to 0.68%) p=0.1075 *Success* • Success in people with a history of treated periodontitis (8 studies) = 89% (95%CI: 82.3-95.7%) • Success in healthy people (4 studies) = 89.2% (95%CI: 81.2-97.2%) Difference in implant success = -11.05% (95%CI: -20.06 to -2.03%) p=0.0163
	Selection Notes: Implant survival = all implants that remained osseointegrated at the time of the last reported follow-up examination Implant success = varied from article to article therefore when authors described “success” or “failure” criteria that included progressive or excessive bone loss, the outcome data was reported in this SR under implant success. If implant success or failure criteria were not described, outcome data were considered to reflect implant survival rates and was reported accordingly Initially looked at all outcomes including bone loss, microbial assessments, peri-implantitis and other complications but most studies included in review did not report these type of outcomes and those studies that did report these outcomes did not report survival or success rates.		**Methodological Score:** **2-**

Evidence Based Healthcare Table

Reference: Kourtis 2004 **Bibliographic Number: 28**

Design	Participants	Exposures	Outcomes
Retrospective case series **Biases/weaknesses:** No adjustment for potential confounding factors No information on excluded people	**Description:** n=405 people had 1692 implants placed in 4 independent private dental practices over the period 1991-2002 (11yrs) in Athens, Greece Variety of implant brands/types (61% IMZ, 35% Frialit-2, 3% Free-Hex, & 1% Frialoc) - all titanium and 3 different surfaces Same treatment protocol All delayed loading except Frialoc implants 171 (42.3%) men Mean age 54.3yrs (range 18-83) 45% of the implants placed in men's mouths Mean clinical observation = 4.6yrs (range 1-12yrs) Mean elapsed time before removal = 40mo Setting: private dental practices (4) **Inclusions:** • as above **Exclusions:** • did not follow the recall programme • refused use of their data **Selection Notes:** Failure = absence of implant	• Age • Gender • Location • Oral hygiene • Smoking • Edentulousness • Bone quality • Bone graft • Prosthesis • Medical record	**Outcome Measures:** Survival rate (%) Differences in survival rates (%; p-value) **Results:** Survival rate = 95.6% (74/1692 failed) Implant failure: • no association with age or gender • more failed in those with metabolic diseases e.g. thyroid gland dysfunction (p<0.001) • no association with diabetes or patients with a "free" medical record • more failed in maxilla than mandible (72% vs. 28% of total failures) p<0.001 • no statistically significant difference in posterior (4.4%) vs. anterior (4.2%) region • more implants failed in smokers compared with non-smokers (p<0.001) • statistically more implants failed in totally & partially edentulous people compared with those with a single tooth implant • statistically significant difference between failures in 'good'-'medium' oral hygiene and 'insufficient' oral hygiene groups **Methodological Score:** **3**

Evidence Based Healthcare Table

Reference: Lemmerman 2005 **Bibliographic Number: 31**

Design	Participants	Exposures	Outcomes
Prospective case series **Biases/weaknesses:** No adjustment for confounders No baseline comparison	**Description:** n=376 people with 1003 consecutively placed implants from 1987-2002 by one practitioner 461 surgeries; 75 people had >1 surgery **Group:** No. in Group: 376 people with 1003 implants Mean Age: 60.6yrs ♂; 58.0yrs ♀ (range15.8-89.2yrs) Gender: 56.8% ♀ Loss to follow-up: 63 (17%) people (8 died, 17 moved, & 38 lost to follow-up) Setting: 1 private periodontal practice **Inclusions:** • as above • people with controlled medical conditions were NOT excluded **Exclusions:** • none stated **Selection Notes:** • other dental conditions/pathologies were treated prior or concurrently with implant therapy • people needing medical attention (e.g. uncontrolled diabetes) were referred to their physician before being considered for implants • smokers were encouraged to quit	• Age • Gender • Prosthesis • Site of placement • Reason of extraction • Bone type • Smoking • Implant characteristics • 1 or 2-stage surgery • Site preparation pre-surgery • Torque-testing • Surgical augmentation • Post-surgical complication • Reason for failure • Current patient status	**Outcome Measures:** Failure rate (%) Difference in failure rate (p-value) **Results:** <u>Failure rate:</u> 6% (61 of 1003 implants) <u>Difference in failure rate:</u> • smoking p=0.945 • gender p=0.608 • bone type p=0.539 • location p=0.127 • post-extraction wait p=0.124 • bony augmentation – no statistical significant difference (p-value not given) • time since implant placement – the only variable that affected the success rate of the implants (p-value not given) **Methodological Score:** **3**

Evidence Based Healthcare Table

Reference: Levin 2006 **Bibliographic Number: 32**

Design	Participants	Exposure	Outcomes
Case series **Biases/weaknesses:** Small sample	**Description:** N=81 consecutive individuals who received dental implants to replace a single molar between 1994 and 2004 Drop-outs: not reported Mean follow-up: 36 (6-125) months	• Complete medical and dental history • Smoking habits • Clinical and X-ray evaluation	**Outcome Measures:** Survival (%) Complications (%)
	Group No. in Group: n=81 Mean Age: 45.6 (18-74) yrs 18.5% (15/81) of patients smoked 87.7% of patients had a mandibular molar replaced with 25.9% of implants placed immediately		**Results:** Overall implant survival rate = 92.6% (75/81) No relation found between complications and failure and time of implant placement or exposure and smoking (statistics not reported)
	Inclusions: People with dental implants replacing a single missing molar between 2 natural teeth and follow-up data of 6 months or more from one institution in Israel		
	Exclusions: None stated		
	Selection Notes: One surgeon performed all the operations		**Methodological Score:** **3**

Evidence Based Healthcare Table

Reference: McDermott 2003 **Bibliographic Number: 16**

Design	Participants	Exposures	Outcomes
Retrospective cohort **Biases/weaknesses:** Smallish sample NB: included as this was not identified	**Description:** People who received a dental implant (Bicon) at the Implant Dentistry Centre, Faulkner Hospital, Boston from May 1992 to July 2000 Between 1992 and 2000, 702 people received implants 25 (4%) of people's records unavailable for various reasons Final sample = 677 people with 2349 implants Select randomly 1 implant per person	• Demographic (including age & gender) • Health status (asa system i-v; presence of diabetes, liver disease or immunosuppression; tobacco use) • Anatomic (location; bone quality; proximity to natural dentition) • Implant (length; diameter; coating; staging; abutment diameter & angulation) • Prosthetic (removable or fixed) • Reconstructive (any reconstructive procedure e.g. Graft, sinus lift) • Other (antibiotic use; who placed the implants & who restored them)	**Outcome Measures:** Frequency of overall complication (%) Risk of complications (HR*; 95%CI; p-value) * Hazard ratio
	Group: N=677 people with 677 implants Median duration of follow-up = 13.1mo (0-85.6) Mean age = 53.5yrs (range 16.9-92.5) Women 50.1% (339) Health status (n=673) 49% ASA status I; 50% status II Medically compromised (n=671) 8.5% Smoking (n=553) 10% Maxilla 63% Anterior location 30% Proximity to 2 natural teeth 39%; to 1 tooth & 1 implant 27% Bone quality 51% type 4; 25% type 3; 23% type 2 Prosthesis 93% crown & fixed Reconstructive procedure 36%		**Results:** <u>Overall complications:</u> Overall frequency of complications = 13.9% (94/677) <u>Risk of overall complications</u>: Multivariate analysis: Age (older vs. younger) • HR=1.0041 (0.98-1.01) p=0.89 Gender (F vs. M) • HR=0.92 (0.58-1.44) p=0.72 Smoking (smoker vs. non-smoker) • HR=2.31 (1.29-4.16) p=0.0051 Staging (1 vs. 2) • HR=2.56 (1.45-4.55) p=0.0013 Prosthesis type (removable vs. fixed) • HR=1.97 (0.92-4.21) p=0.083 Reconstructive procedure (Y vs. N) • HR=1.18 (1.03-1.34) p=0.017 <u>Inflammatory complications:</u> Frequency of inflammatory complications = 10.2% (69/677) NB: 52.2% (36/69) were 'major' complications <u>Risk of inflammatory complications:</u> Multivariate analysis: Mean age • NR Gender • NR
	Inclusions: • As above **Exclusions:** • Charts unavailable for review		
	Selection Notes: • Inflammatory complications include mobility, pain, infection, peri-implantitis, impaired wound healing & gingival recession. • Prosthetic complications include abutment fracture/loosening, O-ring replacement <12mo after prosthesis placement, prosthetic/occlusal adjustment >2wks after restoration & recementation within 2wks of delivery • Operative complications include implant in submandibular/sinus space, & paresthesia lasting at least 7 days after implant surgery		

			Jaw (maxilla vs. mandible) • NR Smoking • HR=3.26 (1.74-6.10) p=0.0002 Staging (1 vs. 2-stage) • HR=3.03 (1.64-5.56) p=0.0004 Reconstructive procedure (Y vs. N) • HR=1.17 (1.001-1.36) p=0.049
			Methodological Score: **2+**

Evidence Based Healthcare Table

Reference: McDermott 2006 **Bibliographic Number: 50**

<table>
<tr><th>Design</th><th>Participants</th><th>Exposures</th><th>Outcomes</th></tr>
<tr>
<td rowspan="4">Retrospective cohort

Biases/weaknesses:
Highly selective sample i.e. only people with implants placed in the posterior maxilla</td>
<td colspan="2">Description:
Source population: all people (n=702) who had Bicon implants placed between 1992- 2000 at a hospital in Boston
4% (25) records unavailable
Eligible population: 677 people with 2349 implants
Study population: 318 people with 762 implants placed in the posterior maxilla
Median follow-up: 22.5 months (range 0-90.9 months)
Setting: Hospital Implant Dentistry Centre</td>
<td rowspan="4">• Maxillary sinus augmentation
• Demographic (including age & gender)
• Health status (asa system i-v; presence of diabetes, liver disease or immunosuppression; tobacco use)
• Anatomic (location; bone quality; proximity to natural dentition)
• Implant (length; diameter; coating; staging; abutment length & angulation)
• Prosthetic type (removable or fixed)
• Reconstructive (any reconstructive procedure e.g. Graft, sinus lift)
• Other (antibiotic use; who placed the implants & who restored them)</td>
<td>Outcome Measures:
Overall survival (%; p-value)*
Hazard ratio of implant failure (HR; 95%CI; p-value)

*adjusted for correlated, clustered observations, NOT adjusted for confounders</td>
</tr>
<tr>
<td>Group 1: MSA§
No. in Group: 167
Mean age: 56.4yrs
Gender: 74 (44.3%) ♀
Tobacco use: 9.1%</td>
<td>Group 2: No MSA§
No. in Group: 151
Mean age: 55.5yrs
Gender: 85 (56.3%) ♀
Tobacco use: 11.9%</td>
<td rowspan="3">Results:
<u>1-yr survival rate</u>:
96.2% (MSA group)
92.6% (No MSA group)
p=0.04

<u>5-yr survival rate</u>:
87.9% (MSA group)
88.0% (No MSA group)
p=0.08

<u>Univariate analysis:</u>
Mean age
• HR=1.0 (95%CI: 0.9-1.1) p=0.09
Gender (♀ vs. ♂)
• HR=1.1 (0.6-1.9) p=0.7
MSA status (MSA vs. No MSA)
• HR=0.7 (0.4-1.2) p=0.2
Smoking (Y vs. N)
• HR=3.9 (2.1-7.5) p<0.001
Operator
• HR=4.2 (1.5-11.2) p=0.005
Implant proximity
• HR=0.2 (0.1-0.3) p<0.001
Prosthetic type
• HR=1.9 (1.5-2.4) p<0.001
Location (premolar)
• HR=0.6 (0.3-0.9) p=0.03
Stage (2- vs. 1-stage)</td>
</tr>
<tr>
<td colspan="2">Inclusions:
• Everyone who had had implant placement in the posterior maxilla* whose charts were available were eligible for study inclusion
*includes premolar and molar regions
Exclusions:
• Charts unavailable for review</td>
</tr>
<tr>
<td colspan="2">Selection Notes:
§Statistically significant differences between ‘MSA’ and ‘No MSA’ groups were observed for implant location (p<0.001), bone quality (p<0.001), implant coating (p<0.001), well size (p=0.008), implant staging (p=0.006), immediate implant (p=0.001), and abutment angle (p=0.009)

Implant failure = implant removal because of implant mobility</td>
</tr>
</table>

			• HR=0.2 (0.1-0.3) p<0.001 <u>Multivariate analysis:</u> MSA vs. No MSA • HR=1.1 (0.6-1.9) p=0.9 Smoker vs. non-smoker • HR=3.5 (1.7-7.2) p<0.001 Premolar vs. molar • HR=0.4 (0.2-0.6) p<0.001 2- vs. 1-stage • HR=0.1 (0.07-0.3) p<0.001 Age • HR=1.02 (0.99-1.05) p=0.22 Gender (♀ vs. ♂) • HR=1.09 (0.61-1.95) p=0.77
			Methodological Score: **2+**

Evidence Based Healthcare Table

Reference: Moheng 2005 **Bibliographic Number: 19**

Design	Participants	Exposure	Outcomes
Prospective cohort **Biases/weaknesses:** Not known how many declined to participate and why Not all potential confounders included Small sample Highly selected sample i.e. older & NOT having a bone graft nor prosthetic difficulties	**Description:** All people who had been treated in Dept of Periodontology (Hospital Ambroise Paré, Marseille, France) between 1997- 1999 who gave informed consent to participate in the study **Group:** No. in Group: 93 participants with 266 implants Mean Age: 60.5yrs (range 18-85yrs) Gender: 57 (61%) women, 36 (39%) men Drop-outs: not reported Follow-up: 2yrs Smoking: 16% 15/93 86% (49/57 women) were menopausal, of which 23% (9) were receiving hormone replacement therapy Comorbidity: only menopausal status, HRT, smoking recorded Setting: Hospital department **Inclusions:** • As above **Exclusions:** • Bone grafts • Prosthetic difficulties	• Serum osteocalcin, urinary pyridinoline & deoxypyridinoline • Age, gender, menopausal status, tobacco use, HRT • Type, form, diameter & length of implant, indication for implant, delayed placement, site, bone quality/density	**Outcome Measures:** Survival (%) Difference in failure rate (p-value) Relative risk of implant failure (RR; p-value) **Results:** Survival = 95.5% (95%CI: 92.5-97.5) at 1 and 2 years Univariate analysis: • Smoking p=0.01 • All other variables – no significant difference Multivariate analysis: • Smoking more likely to fail (RR=14.4, p<0.0001) • Removable prosthesis or single-tooth replacement more likely to fail (RR=9.2, p=0.04) • No association between serum osteocalcin, pyridinoline & deoxypyridinoline, and implant failure (0.29 < p < 0.96) • All other variables not retained in final model **Methodological Score:** **2-**

Evidence Based Healthcare Table

Reference: Moy 2005 **Bibliographic Number: 20**

Design	Participants	Exposure	Outcomes
Retrospective cohort **Biases/weaknesses:** Risk of residual confounding Numbers lost to follow-up not reported	**Description:** Consecutive patients who had implants placed by same surgeon over a 21-yr period (1982-2003) Retrospective chart review Consistent surgical protocol Type of implant placed changed over time Reported that "most" of the cohort were followed-up for up to 20yrs Blinding of patient identities	• Age • Gender • Location • Smoking • Coexisting medical conditions e.g. type I & II diabetes, hypertension, coronary artery disease, asthma, steroids, history of chemotherapy or head & neck radiation therapy, postmenopausal women taking hormone replacement therapy (HRT)	**Outcome Measures:** Difference in failure rates (p-value) Relative risk of implant failure (RR; 95%CI; p-value)
	Group : No. in Group: N=1140 people with 4680 implants Age range 12-94yrs (median = 58yrs) Gender: 59% women; 41% men Coexisting condition: 68% had at least 1 condition; 6% had 3 or more Failures: 170 (15%) people experienced at least 1 failure Setting: University, USA		**Results:** <u>Univariate analysis</u>: Age [60-79yrs vs. <40yrs] RR=2.24 (95%CI: 1.28-3.93) Smoking [vs. not smoking] RR=4.56 (95%CI: 1.03-2.36) Diabetes RR=2.75 (1.46-5.18) Radiotherapy RR=2.73 (1.10-6.81) HRT RR=2.55 (1.72-3.77) Gender, hypertension, coronary artery disease, asthma, steroids, history of chemotherapy – all NS Location: 8.16% failed in maxilla vs. 4.93% failed in mandible (p<0.001) <u>Multiple linear regression:</u> (predictors of # of failed implants/patient) Total implants placed p=0.001 Diabetes p=0.044 HRT p=0.001 <u>Stepwise logistic regression:</u> Diabetes RR=1.94 (p=0.003) Smoking RR=1.39 (p=0.03) Head & neck radiotherapy RR=1.87 (p=0.05) Location (maxilla vs. mand.) RR=1.79 (p=0.001)
	Inclusions: • As above **Exclusions:** • Not reported		
	Selection Notes: "failure" = any condition that led to the removal of implant(s) [conditions included implant mobility, pain, infection, fracture, intolerable paraesthesia, anaesthesia or dysaesthesia, and radiological bone loss of >50%]		**Methodological Score:** **2-**

Evidence Based Healthcare Table

Reference: Mundt 2006 **Bibliographic Number: 12**

Design	Participants	Exposure	Outcomes
Retrospective cohort study **Biases/weaknesses:** Selection bias highly probable (36% of patients not included) Reporting bias possible with retrospective chart review or questionnaire Other confounders not considered e.g. bone quality Blinding not reported	**Description:** N=250 patients with 1024 screw-type tapered dental implants (Tiolox) placed during 1990-1998 by one dentist in a private practice in Germany All participants examined by two clinicians July-Sept 2002 [observations compared with patient charts] Drop-outs: 36% (91/250) patients not included in analysis overall • 21% (53/250) ineligible due to having moved or died • 19% (38/197) refused to participate Mean follow-up: 88.2 months (range 43.6-146.3) Setting: Private dental practice **Group** No. in Group: 159 patients with 663 implants Median Age: 54.1 yrs (range 14.9-80.9 yrs) Gender: 65 men, 94 women 367 implants in placed in the maxilla; 296 in the mandible **Inclusions:** As above **Exclusions:** None stated	• Implant characteristics • Timing of loading • Prosthesis characteristics • Medical history (cardiovascular disease, allergies, blood clotting disorders, diabetes, hepatitis, TB, HIV, thyroid disease, osteoporosis, rheumatism, arthritis/arthrosis) • Smoking status/duration • Questionnaire re oral hygiene i.e. frequency of tooth brushing, use of other oral hygiene products, last dental appointment and reason for appointment	**Outcome Measures:** Cumulative survival (%) Risk of implant failure (Hazard ratio [HR]; 95% confidence interval [95%CI]) **Results:** <u>Cumulative survival:</u> independent model considering all implants • 97.6% during 1st year • 95.9% after 5 years • 91.8% after 10 years dependent model considering 1 implant per patient • 98.1% during 1st year • 96.8% after 5 years • 93.5% after 10 years <u>Risk of implant failure</u>: Multivariate model considering all implants Duration of smoking (continuous) • HR=1.04 (1.01-1.07) Gender (ref: male) • HR=0.46 (95%CI: 0.17-1.23) Age (continuous) • HR=0.98 (0.94-1.02) Region (ref: post mandible) Ant maxilla • HR=1.52 (0.43-5.37) Post maxilla • HR=2.71 (0.87-8.47) Ant mandible • HR=0.69 (0.13-3.58)

			Prosthesis (ref: fixed) • HR=0.72 (0.26-1.93) Multivariate model considering 1 implant per patient Duration of smoking • HR=1.04 (1.00-1.08) Gender • HR=0.79 (0.17-3.59) Age • HR=1.02 (0.95-1.10) Diseases, oral health behaviour, implant length, region of placement & suprastructure type – all reported as not significant
	Selection Notes: Implant failure = need for implant removal or evidence of fracture		**Methodological Score:** **2-**

Evidence Based Healthcare Table

Reference: Noguerol 2006 **Bibliographic Number: 21**

Design	Participants	Exposure	Outcomes
Retrospective cohort study **Biases/weaknesses:** Selection process & baseline demographic data not reported	**Description:** N=316 consecutive patients with 1084 Brånemark® implants in a single periodontal clinic (Granada, Spain) over a 10-yr period. No information on actual dates or selection process. All implants non-threaded titanium surface All patients with periodontitis were treated before implant placement Periotest® accuracy determined by area under ROC curve Failure = removed according to clinical criteria of mobility, pain & gingival inflammation	• Age • Gender • Smoking • Periodontal status & degree of periodontitis • Implant surface, length & diameter • Location • Bone quality • PTVs (Periotest® values) & horizontal/vertical bone loss by X-ray at stage-1 & -2 surgery	**Outcome Measures:** Risk of early implant failure (OR; 95%CI)* *OR = odds ratio CI = confidence interval
	Group : No. in Group: 316 people with 1084 implants Mean Age: not reported Gender: not reported Drop-outs: not reported Comorbidities: not reported		**Results:** <u>Risk of early implant failure:</u> Bivariate analysis: Age, smoking, location, location area, bone type, implant length & diameter, and PTV (cut-off -2) – all considered significant Multivariate analysis: Age [≤60yrs vs. >60yrs] • OR=4.53 (95%CI: 1.34-15.27) Smoking [>20cigs/day vs. <20cigs/day] • OR=2.50 (95%CI: 1.3-4.79) Oral status [periodontal vs. edentulous/non-periodontal] • OR=2.36 (95%CI: 0.9-6.21) Bone quality [type I, III & IV vs. type II] • OR=1.93 (95%CI: 1.01-3.7)
	Inclusions: • As above **Exclusions:** • Not reported		
	Selection Notes: NB: Reported that "[t]he gender, menopause, and periodontal status were clearly non-significant."		**Methodological Score:** **2-**

Evidence Based Healthcare Table

Reference: Ong 2008 **Bibliographic Number: 47**

Design Description	Participants	Exposures	Outcomes
Systematic review **Biases/weaknesses:** 6 of the 9 studies assessed as being of high risk of bias Heterogeneity of study design, follow-up period, & definition of survival/success/peri-implantitis	**Description:** 4448 publications identified by search. N=10 (9 studies) Studies included: Karoussis 2003, Mengel 2005, Hardt 2002, Evian 2004, Rosenberg 2004, Roos-Jånsaker 2006a, Roos-Jånsaker 2006b, Watson 1999, Brocard 2000, and Hänggi 2005. Search strategy: Ovid MEDLINE, EMBASE up to March 2006; comprehensive & highly sensitive search + bibliographies of all included articles and relevant reviews were checked; author's contacted when needed; no language restriction. Methodological quality: All the studies were rated as having a high risk of bias except Mengel 2005 [cohort], Hardt 2002 [case series] & Evian 2004 [case series] which were classified as medium risk. Publication bias mentioned – no formal analysis. **Inclusions:** • all longitudinal studies (i.e. RCTs, CCT, cohort, case-control and case series) reporting on endosseous dental implant survival and/or success • case series needed consecutive patients • at least 6 months of loading • at least 10 participants • titanium implants with any surface • all definitions of survival/success/peri-implantitis were considered **Exclusions:** • letters and reviews • medically compromised participants e.g. people with cancer, uncontrolled diabetes • bone/soft tissue grafts augmentation procedures • transmandibular or zygomatic implants or implants used for non-dental uses e.g. orthodontic anchorage	• Periodontitis	**Outcome Measures:** Survival Success Bone loss Peri-implantitis **Results: [see table 1 & 2 below]** <u>Survival</u>: reported in 5 studies All studies except Watson 1999 showed better implant survival for the non-periodontitis group compared with the treated periodontitis group. However, a statistically significant difference was only found in Evian 2004 & Roos-Jånsaker 2006a. <u>Success:</u> only reported in 5 studies All studies except Watson 1999 showed better implant success for the non-periodontitis group compared with the treated periodontitis group. However, a statistically significant difference was only found in Karoussis 2003 ($p<0.025$), while no statistical significance was found in Mengel 2005. For the rest, analysis was either not carried out (Watson 1999, Brocard 2000) or not reported (Rosenberg 2004). <u>Bone-level changes</u>: only reported in 5 studies. All studies showed less bone loss in the non-periodontitis group in comparison to the treated periodontitis group. However, a statistically significant difference was only reported in Hardt 2002 ($p=0.029$) and a borderline significance was reported in Hänggi 2005 ($p=0.058$). The rest of the studies did not find any statistically significant difference (Mengel 2005, Roos-Jånsaker 2006b) or the data was not reported (Karoussis 2003). <u>Peri-implantitis</u>: only reported in 3 studies All three studies reported lower occurrences of peri-implantitis in the non-periodontitis group in comparison with the treated periodontitis group. And, a statistically

			significant difference was reported in Karoussis 2003 (p=0.002) and Roos-Jånsaker 2006b (p=0.05; OR = 4.7; 95%CI: 1.0-22).
	Selection Notes:		**Methodological Score:** **2-**

Table 1: SURVIVAL

Study	Follow-up (yrs)	Periodontitis	Non-periodontitis	Stats	Design	Risk of bias
Roos-Jånsaker 2006a,b	9-14	16events/94pts	2events/62 pts	P=0.01	Case series	High
Evian 2004	>10	79.22%	91.67%	P=0.0213	Case series	Medium
Karoussis 2003	10	90.5%	96.5%	NS	Cohort	High
Hardt 2002	5	92%	96.7%	NR	Case series	Medium
Watson 1999	4	100%	100%	NA	Cohort†	High

Table 2: SUCCESS

Study	Follow-up (yrs)	Periodontitis	Non-periodontitis	Stats	Design	Risk of bias
Mengel 2005	3	95.7% (maxilla) 100% (mandible)	100%	NS	Cohort	Medium
Rosenberg 2004	13	90.7%	93.7%	NR	Case series	High
Karoussis 2003	10	52.4%	79.1%	P<0.025	Cohort	High
Brocard 2000	7	74.4%	88.8%	NA	Case series†	High
Watson 1999	4	100%	56%	NA	Cohort†	High

†subgroup analysis

NS = not significant

NA = no statistical analysis

NR = not reported

Evidence Based Healthcare Table

Reference: Roos-Jansaker 2006 **Bibliographic Number: 23**

<table>
<tr><th>Design Description</th><th>Participants</th><th>Exposure</th><th>Outcomes</th></tr>
<tr><td rowspan="5">Cohort study type analysis of case series data

Biases/weaknesses:
Uniform periodontal treatment program not applied during 9-14yr period

Recall bias possible

32% of total population not included</td><td>Description:
N=294 patients with dental implants (Brånemark System®) placed during 1988-1992 at the Public Dental Health Service in Kristianstad, Sweden.
All participants examined by one examiner between 2000 and 2002.
Drop-outs:
7% (22/294) patients ineligible due to having died
20% (54/272) patients refused to participate
5% (58/1057) implants excluded
Follow-up: 9-14 years after suprastructure placement
Setting: University</td><td rowspan="5">• Age, gender, years of education
• Edentulous/dentate at time of implant placement
• Total dental visits since placement suprastructure
• Smoking habits
• Medical history
• Medication
• Number of implants placed
• Implant position (mandible/maxilla; posterior/anterior)
• Plaque score
• Bleeding on probing (BOP) score
• % remaining teeth before implant placement with bone loss ≥4mm</td><td>Outcome Measures:
Overall survival (%)

Factors associated with loss (p-value)</td></tr>
<tr><td>Group
No. in Group: 218 patients with 1057 implants
Mean age: 65.6 (29-92) years
Gender: 50.5% women
29.4% edentulous
524 implants in maxilla & 533 in mandible
14.6% had implants in both jaws
Smoking: 26% (57) current smokers; 37% (81) former smokers; 37% (80) never smoked
4.6% (10) had diabetes
Mean visits to dental clinic 15.4 (range 0-60)</td><td>Results:
<u>Overall survival:</u> 95.7%

<u>Factors associated with loss:</u>
• %teeth with bone loss ≥4mm (indication of previous history of periodontitis) significant p=0.01
• smoking status (never: current/ex-smoker) p=0.16
• maxillary implants in people with ≥5 implants placed significant but explained by confounding by %teeth with bone loss ≥4mm</td></tr>
<tr><td>Inclusions:
As above</td><td></td></tr>
<tr><td>Exclusions:
Implants (N=58) not used to support suprastructure (“sleeping implants”) or they were lost during the follow-up period.</td><td></td></tr>
<tr><td>Selection Notes:</td><td>Methodological Score:
2-</td></tr>
</table>

Evidence Based Healthcare Table

Reference: Sánchez-Pérez 2007 **Bibliographic Number: 29**

Design Description	Participants	Exposure	Outcomes
Case series **Biases/weaknesses:** Unclear exclusion criteria Small sample size	**Description:** 66 consecutive patients who had 165 dental implants placed over a 5-yr period (1998-2002) in private dental practice, Murcia, Spain Same surgeon & implant type All had 2-stage surgery Check-up: at time prosthesis placed, 1wk, 1mo, 3mo, & every 6mo for up to 5yrs Measure plaque/gingival/papillar bleeding index, probing depth, mobility, marginal bone level, & smoking status	• Smoking • Bone quality • Prosthesis type • Location	**Outcome Measures:** Success rate Failure rate Difference in success/failure rates (p-value) Relative risk of failure (RR)
	Group : No. in Group: 66 people with 165 implants Mean Age: 43.4yrs (range 15-71) Gender: not reported 26 non-smokers; 40 smokers Location: 64% maxilla; 36% mandible Suprastructure: 72% fixed prosthesis; 28% overdentures Follow-up: 5yrs Smoking subgroups: NS= never smoked or stopped over 10yrs ago [n=26] LS=light smokers (<10/day) [n=23] MS=moderate smokers (10-20/day) [n=11] HS=heavy smokers (>20/day) [n=6]		**Results:** Overall success rate = 90.3% Failure rate = 9.7% (16/165 implants) Significant (p<0.001) difference in success rates between smokers & non-smokers (84.2% vs. 98.6%) Significant (p<0.05) difference in failure rates between all smoking subgroups except MS vs. HS Relative risk (no CIs) of failure of implant: RR [S vs. NS] = 11.2 RR [LS vs. NS] = 6.5 RR [MS vs. NS] = 8.5 RR [HS vs. NS] = 21.8 No significant difference among bone quality & success rates (p>0.05) No significant difference in success with regard to kind of prosthesis or location of implant placement (p>0.05).
	Inclusions: • as above **Exclusions:** • "any relative or absolute systemic or local contraindications" • bone augmentation		
	Selection Notes: Success = immobile, no peri-implant radiolucency, vertical bone loss <0.2mm/yr, no pain, infection, neuropathy, paraesthesia or mandibular canal problem, and survival rate = 85% at 5yrs and success = 80% at 10yrs		**Methodological Score:** **3**

Evidence Based Healthcare Table

Reference: Shou 2006 **Bibliographic Number: 49**

Design Description	Participants	Exposures	Outcomes
Systematic review **Biases/weaknesses:** Limited number of studies Both assessed to be at high risk of bias Different definitions of periodontitis Heterogeneity/publication bias not addressed	**Description:** 2116 publications identified by search N=2 studies included with total of 103 participants Studies included: Hardt 2002, Karoussis 2003 Methodological assessment: both assessed to be 'high risk' of bias Search MEDLINE only (1980-2005) + handsearch 20 implant-related journals (1980-2005) + bibliographies of selected articles Broad search strategy Heterogeneity/publication bias not reported Random effects model **Inclusions:** • prospective and retrospective cohort with at least 5yrs follow up • partially edentulous with periodontitis-associated tooth loss vs partially edentulous with non-periodontitis-associated tooth loss • n>10 participants • outcomes: loss of suprastructures/implants*; per-implant marginal bone loss; peri-implantitis** **Exclusions:** • non-human studies **Selection Notes:** *Loss of implants = implant mobility in previously osseointegrated implants, & removal of implant due to progressive peri-implant marginal bone loss and infection **Peri-implantitis = progressive peri-implant marginal bone loss associated with infection signs	• Periodontitis • Peri-implantitis • Marginal bone loss	**Outcome Measures:** Risk of implant loss (RR; 95% CI) Risk of peri-implantitis (RR; 95% CI) Mean marginal bone loss (WMD†; 95% CI) Risk of suprastructure failure (RR; 95% CI) †weighted mean difference **Results:** <u>Implant loss</u>: RR=2.24 (0.71-7.04) at 5yr follow-up (both studies) RR=3.75 (0.74-19.02) at 10yr follow-up (Hardt 2002) <u>Risk of peri-implantitis</u>: RR=9.00 (3.94-20.57) at 10yr follow-up (Karoussis 2003) <u>Mean marginal bone loss:</u> WMD=0.50 (0.06-0.94) at 5yr follow-up (Hardt 2002) <u>Risk of suprastructure failure</u>: RR=5.00 (95% CI: 0.25-99.16) at 5yr follow-up **Methodological Score:** **2-**

Evidence Based Healthcare Table

Reference: Schou 2008 **Bibliographic Number: 48**

Design Description	Participants	Exposures	Outcomes
Systematic review **Biases/weaknesses:** No methodological assessment Relative risks only based on 2 studies Risk of publication bias cannot be excluded Significant heterogeneity of participants & treatments	**Description:** 2258 publications identified by search N=23 studies with 5-799 participants Studies included: Hardt 2002, Karoussis 2003, Ericsson 1986, Nevins 1995, Ellegaard 1997a, Ellegaard 1997b, Daelemans 1997, Sbordone 1999, Schwartz-Arad 1998, Buchmann 1999, Mengel 1996, Mengel 2001, Yi 2001, Leonhardt 2002, Feloutzis 2003, Baelum 2004, Wennstrom 2004, Karoussis 2004, Janson 2005, Mengel 2005a, Mengel 2005b, Cordano 2005, Ellegaard 2006. No assessment of methodological quality Broad search strategy on MEDLINE (Pubmed) (1980-2006) + handsearch relevant journals + bibliographies of selected articles Hetereogeneity ++ therefore narrative analysis Publication bias not reported All random effects model except marginal bone loss	• Periodontitis-associated tooth loss	**Outcome Measures:** Suprastructure survival rate (%) Risk of suprastructure loss (RR; 95%CI) Implant survival rate (%) Risk of implant loss (RR; 95%CI) Risk of peri-implantitis (RR; 95%CI) Mean marginal bone loss (WMD; 95%CI) NB: all RRs & WMD calculated from Shou 2006 (see separate evidence table)
	Inclusions: • Prospective and retrospective cohort studies of implant placement in partially and totally edentulous individuals with periodontitis-associated tooth loss • Follow-up >1 year • More than 5 participants • Titanium implants • Outcomes: loss of suprastructures, loss of implants (implant mobility of previous clinically osseointegrated implants, or removal of implant due to progressive peri-implant marginal bone loss and infection), loss of teeth, health status of peri-implant tissues, health status of periodontal tissues		**Results:** Suprastructure survival rate: 92-100% after 5 years • No statistically significant difference in the 5-year survival rates of suprastructures in participants with periodontitis-associated and non- periodontitis-associated tooth loss (RR=5.00 (95%CI:0.25-99.16), p=0.29) **Hardt 2002** • Survival rates of suprastructures in participants with tooth loss due to chronic and aggressive periodontitis in 3 studies with a follow-up period of 3- to 5-years from the same research group was 100% **Mengel 1996, Mengel 2001, Mengel 2005a** Implant survival rate: >90% after 10 years in most studies • Comparable survival rates of implants in people with periodontitis-associated and non- periodontitis-associated tooth loss have been reported in short-term studies **Mengel 2005a, Cordanro 2005, Mengel 2005b** • No statistically significant difference in the 5-year survival rates of implants in participants with periodontitis-associated and non- periodontitis-associated tooth loss (RR=2.24 (95%CI:0.71-7.04), p=0.17) **Hardt 2002, Karoussis 2003** • No statistically significant difference in the 10-year survival rates of implants in participants with periodontitis-associated and non- periodontitis-associated tooth loss (RR=3.75 (95%CI: 0.74-19.02),
	Exclusions: None reported		

			p=0.11) **Karoussis 2003** • Survival rates of implants in people with tooth loss due to chronic and aggressive periodontitis were above 90% in 3 studies with a follow-up period of 3- to 5-years from the same research group **Mengel 1996, Mengel 2001, Mengel 2005a** • Comparable survival rates of implants placed in pristine and regenerated bone have been found in 2 studies of periodontitis-susceptible people with a 3- to 5-year follow-up period from the same research group **Ellegaard 1997, 2006** Survival rates of teeth were seldom reported, but when reported, they were generally high ie 87-95% after 10 years **Leonhardt 2002, Karoussis 2004** Health status of peri-implant tissues • Statistically significantly more people were affected by peri-implantitis in the group with periodontitis-associated tooth loss compared with the group with non- periodontitis-associated tooth loss (RR=9.0[random] (95%CI: 3.94-20.57), p<0.00001) **Karoussis 2003** • Statistically significantly more people were affected by peri-implant marginal bone loss in the group with periodontitis-associated tooth loss compared with the group with non- periodontitis-associated tooth loss (WMD[fixed]=0.50 (95%CI: 0.06-0.94), p=0.03) **Hardt 2002**
	Selection Notes:		**Methodological Score:** **2-**

Evidence Based Healthcare Table

Reference: Sjostrum 2007 **Bibliographic Number: 24**

Design Description	Participants	Exposure	Outcomes
Prospective cohort **Biases/weaknesses:** Small sample Limited number of possible confounding factors investigated e.g. bone quality ORs have large CIs i.e. imprecise	**Description:** 29 consecutively admitted people with totally edentulous maxillae who were treated with reconstruction with free autogenous iliac bone graft and delayed placement of titanium implants with a turned surface (Standard® and Mark II® Brånemark System) Mean age = 58 yrs (range 48-73yrs) Gender: 21 women; 8 men Drop-outs: 4 (1 died, 1 refused to participate, & 2 moved)	• Gender • Age • Smoking • Location • Bone resorption	**Outcome Measures:** Cumulative survival rate (%) Risk of failure (Odds ratio [OR]; 95% CI)
	Group : No. in Group: 25 people with 192 implants Gender: 17 women; 8 men Mean Age: 55yrs (range 48-65yrs) 20 of 192 implants failed during f/u (12 'early' and 8 'late')		**Results:** Cumulative survival rate = 90.3% (at 3yrs f/u) Univariate analysis: Gender (M: F)) OR = 10.18 (95%CI: 1.33-77.90) Bone resorption (3-5:6) OR = 5.56 (1.93-16.07) Smoking (NS: S) OR = 0.48 (0.15-1.50) Position (2nd premolar + canine + lateral incisor: central incisor) OR = 2.61 (1.01-6.75) Reconstruction (Interpositional: Onlay/Inlay) OR = 3.69 (0.48-28.73) Multivariate analysis: Gender (M: F)) OR = 8.22 (95%CI: 1.04-64.95) Bone resorption (3-5:6) OR = 3.91 (1.13-13.48) Smoking (NS: S) OR = 0.42 (0.12-1.24) Position (2nd premolar + canine + lateral incisor: central incisor) OR = 2.05 (0.69-6.12)
	Inclusions: • **Exclusions:** •		
	Selection Notes:		**Methodological Score:** **2-**

Evidence Based Healthcare Table

Reference: Strietzel, 2007 **Bibliographic Number: 15**

Design Description	Studies	Exposure	Outcomes
Systematic review and meta-analysis of observational studies. **Biases/weaknesses:** No methodological assessment of individual studies	**Description:** Number of studies: N=29 (meta-analysis); N=35 (systematic review) Total number of patients in the studies: n=16605 implants; n=3383 patients Databases used: Medline and Embase (1989-2005) in English and manual search of three German language peer-reviewed dental journals (1968/1996/1999-2005) Description of the methodological assessment of studies: none reported Length of treatment: any period of follow-up Description of comparison (placebo): not smoking Co-interventions: none	• Smoking status • Sinus augmentation	**Outcome Measures:** Meta-analysis: Odds ratios (OR) of failure in smokers compared with rate in non-smokers + 95% confidence intervals (95% CI). Systematic review: Narrative synthesis
	Inclusions: SR/meta-analyses, RCTs, prospective and retrospective clinical studies, cohort studies, and case-control studies that include implant survival rates or numbers of failed implants on a patient- or implant-related basis and numbers of smokers and non-smokers. Also studies of implant survival after bone augmentation procedures in smokers compared with non-smokers. Other publications that didn't meet the above criteria were included in a separate systematic review if ORs, RRs or HRs for implant failures or biological complications among smokers were reported.		**Results:** **Meta-analysis** Implant-related failure (18 studies): OR = 2.38 (95% CI: 1.93-2.93) random effects model Patient-related failure (10 studies): OR = 2.64 (95% CI: 1.70-4.09) fixed effects model
	Exclusions: Case reports, animal/in vitro studies, educational statements, expert opinion or did not match inclusion criteria or the focussed question.		
	Selection Notes: Studies included in meta-analysis: Bain 1996, Bain 1993, Balshi 1999, Berge 2000, Beschnidt 2003, De Bruyn 1994, De Bruyn 1999, Geurs 2001, Gorman 1994, Grunder 1999, Jones 1999, Kan 2002, Karoussis 2003, Keller 1999, Kronstrom 2001, Kumar 2002, Lambert 2000, Mayfield 2001, Minsk 1998, Moheng 2005, Olson 2000a, Ortorp 2002, Penarrocha 2002, Schwartz-Arad 2000, Schwartz-Arad 2002, Van Steenberghe 2004, Wallace 2000, Widmark 2001. Studies included for systematic review: Aalam 2005, Ataoglu 2002, Attard 2002, Baelum 2004, Bain 2002, Carlsson 2000, Chuang 2002b, Eckert 2001, Feloutzis 2003, Galindo-Moreno 2005, Gruica 2004, Haas 1996, Karoussis		**Methodological Score: 2-**

	2004, Kourtis 2004, Lemmermen 2005, Leonhardt 2003, Levin 2004, Lindquist 1996, Lindquist 1997, McDermott 2003, Moy 2005, Nitzan 2005, Oates 2004, Ortorp 2004, Penarroucha 2004, Schwartz-Arad 2005a, Schwartz-Arad 2005b, Strietzel 2001, Strietzel 2004, Wennstrom 2004a, Wennstrom 2004b, Weyant 1994, Wilson 1999, Woo 2004, Zitzman 1999.		

Evidence Based Healthcare Table

Reference: Suslarla 2008 **Bibliographic Number: 17**

<table>
<tr><th>Design Description</th><th>Participants</th><th>Exposures</th><th>Outcomes</th></tr>
<tr><td rowspan="5">Retrospective cohort

Biases/weaknesses:
Unclear whether the study population is everyone who had an implant placed between 2001-3 or a sample of this population
Loss to follow-up may introduce bias</td><td colspan="2">Description: People who had at least one Bicon dental implant placed at a private dental practice, Boston, during period 1992-2003.
• n=855 people with 2826 implants
Delayed loading group had implants placed between 1992-2000, those in the immediate loading group had implants placed between 2001-2003.
Lost to follow-up: not reported
Setting: private dental practice</td><td rowspan="5">• Loading of implant (immediate vs. delayed)*
• Age
• Gender
• Smoking
• Bone quality (type I-IV)
• Reconstructive parameters (sinus lift, barrier membrane, bone graft, ridge split & graft materials)
• Implant characteristics</td><td rowspan="2">Outcome Measures:
Implant survival at one year (%; 95%CI; p-value)
Relative risk of failure at 1 year (RR; 95%CI)</td></tr>
<tr><td>Group 1: delayed loading
No in group: 677 (79.2%) people with 2349 (83.1%) implants
Mean age: 53.1yrs (range 16.9-92.5)
Gender: 49.6% men
Smoking: 10.3%
Immediate implant placement: 10.3%
Location: 60.2% in maxilla; 31.1% anterior
Bone quality: 0.9% type I, 26.6% type II, 20.2% type III, 52.4% type IV
Dentoalveolar reconstructive procedure: 36.1%</td><td>Group 2: immediate loading
No in group: 178 (20.8%) people with 477 (16.9%) implants
Mean age: 53.0yrs (range 14.9-91.4)
Gender: 47.8% men
Smoking: 9.0%
Immediate implant placement: 50.1%
Location: 75.7% in maxilla; 53% anterior
Bone quality: 4.3% type I, 9.8% type II, 35.4% type III, 50.6% type IV
Dentoalveolar reconstructive procedure: 9.0%</td><td>Results:
<u>1-yr survival:</u>
95.5% (95%CI: 94.6-96.4) delayed loading group
90.3% (95%CI: 87-93.7) immediate loading group
p<0.01

<u>Risk of failure:</u>
Univariate analysis:
• immediate loading HR=1.9 (95%CI: 1.3-2.8) p<0.01
• age HR=1.0 (95%CI: 1.0-1.0) p=0.26
• gender (F) HR=1.1 (95%CI: 0.81-1.5) p=0.51
• smoking HR=2.5 (95%CI: 1.7-3.6) p<0.01
• maxilla HR=1.7 (95%CI: 1.2-2.3) p<0.01
• immediate implant placement HR=1.4 (95%CI: 0.92-2.0) p=0.12

Multivariate analysis:
• immediate loading HR=2.7 (95%CI: 1.2-5.9) p=0.01
• age HR=1.00 (95%CI: 0.98-1.0) p=0.57
• gender (F) HR=1.10 (95%CI: 0.78-1.5) p=0.59
• smoking</td></tr>
<tr><td colspan="2">Statistically significant differences between the two groups in location, dentoalveolar reconstructive procedure, immediate implant placement & implant length, diameter, coating & well size (p<0.01)</td></tr>
<tr><td colspan="2">Inclusions:
• as above
Exclusions:
• missing records</td></tr>
<tr><td colspan="2">Selection Notes:
*immediate loading =implant provisionally restored & stabilised by bonding to adjacent teeth or implants & placed into functional occlusion the same day as implant placement
*delayed loading =implant restored at some time interval after implant placement
Implant failure = removal of the implant</td></tr>
</table>

			HR=2.6 (95%CI: 1.8-3.9) p<0.01 • maxilla HR=1.9 (95%CI: 1.3-2.9) p<0.01 • immediate implant placement HR=1.04 (95%CI: 0.61-1.8) p=0.88
			Methodological Score: **2+**

Evidence Based Healthcare Table

Reference: Sverzut 2008 **Bibliographic Number: 25**

Design Description	Participants	Exposures	Outcomes
Retrospective cohort **Biases/weaknesses:** Excluded implants not reported No explicit definition of implant loss Some possible confounders not included e.g. bone quality, oral health	**Description:** All people who had implants placed between 1996-2004 at the Division of Oral & Maxillofacial Surgery, State University of Campinas, Sao Paulo, Brazil • n=650 people with 1628 implants All implants followed a 2-stage surgical procedure (submerged implants). Implants were evaluated from the placement of the implants (1st surgical phase) until the procedure for reopening (2nd surgical phase). **Group:** No in group: n=650 people with 1628 implants Mean age: 42.7yrs (range 13-84) Gender: not reported Mean follow-up: 249 days [between 1st- & 2nd-stage surgery] 12% (76/650) were smokers 12% (197/1628) of implants placed in smokers 23% (397/1682) of implants placed in reconstructed areas **Inclusions:** • dental implant placement in patients who had been subjected to the second surgical phase **Exclusions:** • missing/incomplete files • not yet had implant placed • implant which were not subjected to second surgical phase • implants placed but had abandoned the treatment • had their implants placed with a nonsubmerged protocol **Selection Notes:** *location 1 = maxilla or mandible location 2 = anterior or posterior location 3 = maxillary anterior, maxillary posterior, mandibular anterior, and mandibular posterior	• Smoking • Age • Gender • Location of placement* • Post-operative infection • Dentoalveolar reconstructive procedures (type & origin of bone graft, sinus lift, alveolar distraction, lateralisation of inferior alveolar nerve)	**Outcome Measures:** Implant loss rate (%) Risk of failure (HR*; p-value) *HR=hazards ratio **Results:** <u>Implant loss rate:</u> 2.81% in the smoking group 3.32% in the non-smoking group <u>Risk of failure:</u> Univariate analysis: (p<0.25 = significant) gender HR=1.2160 p=0.4957 age HR=1.2600 p=0.2588 tobacco use HR=1.2390 p=0.5994 chin bone graft HR=0.5350 p=0.1640 alveolar distraction HR=6.7910 p=0.0083 infection HR=23.6150 p<0.0001 implant length HR=0.5980 p=0.0116 location 2 HR=0.4670 p=0.0091 location 3 HR=0.8530 p=0.1784 Multivariate analysis (p<0.05 = significant) gender HR=1.2550 p=0.4524 age HR=1.0750 p=0.7358 alveolar distraction HR=7.1740 p=0.0073 infection HR=25.0230 p<0.0001 length HR=0.4720 p=0.0006 location 3 HR=0.3900 p=0.0023 **Methodological Score:** **2-**

Evidence Based Healthcare Table

Reference: Wagenberg 2006 **Bibliographic Number: 26**

Design Description

Retrospective cohort-type analysis of case series

Biases/weaknesses:
Cannot exclude confounding
Poorly reported

Participants

Description: Consecutive patients who had implants* placed immediately into fresh extraction sockets by a single periodontist between 1988-2004.

* Nobel Biocare & Implant Innovations/3i

Group:
No. in Group: 891 consecutive patients with 1925 implants
Mean Age: 57.9yrs (range 14-94yrs)
Gender: 48% (381) men; 52% (510) women
Mean follow-up: 71 months (range 12-193 months) after final prosthesis fitted
Sinus lift: 121 patients with 161 implants
As of Dec 2004, 1854 implants had been restored for at least a year
Setting: University

Inclusions:

- implants achieved apical & lateral stabilisation
- lack of residual infection
- continuous function for 1 year post-restoration (NB if implant failed before placement of restoration then it was considered as a failure prior to final restoration)

Exclusions:

- none stated

†

Location	Failure rate (%)
Mandibular incisors	7.69
Maxillary molars	6.44
Mandibular molars	4.95
Mandibular premolars	4.87
Mandibular canines	3.33
Maxillary premolars	2.81
Maxillary incisors	2.13
Maxillary canines	2.07

Exposure

- Age
- Gender
- Past medical history
- Smoking
- Medication
- Allergies
- Reason for tooth extraction
- Location of implant
- Other surgery
- Implant size & manufacturer

Outcomes

Outcome Measures:
Survival rate (%)
Risk of failure (%; p-value)

Results:
Survival:
Overall survival = 96%
Risk of failure:
Smoking vs. non-smoking (5.6% vs.3.7%; p=0.342)
Women vs. men (3.1% vs. 5.2%; RR=1.65 (95%CI: 1.04-2.61), p=0.0314)
A significant difference in failure rates between implants placed at the sites of periodontally diseased teeth and those placed in non-diseased sites (8.2% vs. 3.7%; RR=2.3; p=0.02)
A significant difference in failure rates between those people unable to take post-surgical penicillin and those who are able to (RR=3.34; p<0.01)
A significant difference in failure rates by location of implant placement (p=0.001)†
No correlation between implant failure & age (p>0.6), any medication (p=0.895), any medical condition (p=0.967), number of implants supporting restorations (single vs. multiple; p=0.356)

Methodological Score:
2-

Evidence Based Healthcare Table

Reference: Woo 2004 **Bibliographic Number: 22**

Design Description	Participants	Exposure	Outcomes
Retrospective cohort **Biases/weaknesses:** Risk of residual confounding e.g. oral health nor reason for tooth loss included as potential confounders High risk of selection bias – only 'successful' DRPs included in study	**Description:** All people (n=702) who had dental implants (Bicon) placed at the Implant Dentistry Centre, Boston between 1992 -2000 Records not available for 25 (3.6%) people Eligible population = 677 people with 2349 implants 1 implant randomly selected from each person (method of selection not described) Setting: University **Group :** No. in Group: 677 people with 677 implants Mean Age: 53.5yrs (range 16-92yrs) Gender: 49.9% men (338/677) DRP*: 35.8% (242/677) ASA† I: 48.9% (329/338) ASA II: 50.2% (338/673) Tobacco use: 10.3% (57/553) Medically compromised: 8.5% (57/671) **Inclusions:** • as above • records available for review **Exclusions:** • none reported **Selection Notes:** Implant failure = removal of implant *DRP = dentoalveolar reconstruction procedures – this includes internal or lateral sinus lifts, barrier membranes, local autologous bone grafts with or without bone substitutes, bone substitute grafts, & ridge-split procedures †ASA = American Society of Anaesthesia (ASA) status [ASA 1 = healthy, ASA 2 = mild systemic disease or ASA, 3 = moderate or severe systemic disease]	• Dentoalveolar reconstruction procedures (DRP) • Age & gender • Health status • Implant position • Bone quality (types I-IV) • Proximity to other teeth/implants • Implant characteristics • Prosthesis type	**Outcome Measures:** Cumulative survival rate (%) Risk of implant failure (HR; 95%CI)* *HR = hazard ratio 95%CI = 95% confidence interval **Results:** <u>1-yr survival rate:</u> 95.1% (95%CI: 92.9-97.4%) without DRP 95.4% (95%CI: 92.6-98.2%) with DRP <u>5-yr survival rate:</u> 91.0 % (95%CI: 86.5-95.5%) without DRP 87.5% (95%CI: 76.5-98.5%) with DRP • differences in survival at 1- & 5-yrs not statistically significant (p≥0.86) <u>Risk of failure:</u> Bivariate analysis • DRP p=0.74 • Tobacco use p=0.007 • Implant length p=0.09 • Staging p=0.009 • Prosthesis type p=0.07 Multivariate analysis (adjusted for age, gender, DRP, tobacco, implant length, prosthesis type, & implant staging) Tobacco use [S vs. NS] • HR=4.4 (95%CI: 2.0-9.8) p<0.001 Staging [2 vs. 1] • HR=0.3 (95%CI: 0.1-0.8) p=0.009 DRP [Y vs. N] • HR=1.4 (95%CI: 0.7-2.9) p=0.32 Age [old vs. young]

			• HR=1.0 (95%CI: 1.0-1.03) p=0.83 Gender [F vs. M] • HR=0.7 (95%CI: 0.3-1.4) p=0.32 Prosthesis [removable vs. fixed] • HR=1.3 (95%CI: 0.4-4.7) p=0.65
			Methodological Score: **2-**

Appendix C:

Exclusion Table:

Paper	Reason for Exclusion
Albrektsson, T., J. Gottlow, et al. (2007). "Survival of NobelDirect implants: an analysis of 550 consecutively placed implants at 18 different clinical centers." Clinical Implant Dentistry & Related Research 9(2): 65-70.	No risk factor analysis
Amorim, M. A. L., L. Takayama, et al. (2006). "Comparative study of axial and femoral bone mineral density and parameters of mandibular bone quality in patients receiving dental implants.[see comment][republished in Osteoporos Int. 2007 May;18(5):703-9; PMID: 17506127]." Osteoporosis International 17(10): 1494-500.	Survival was a secondary outcome
Arvidson, K., O. Esselin, et al. (2008). "Early loading of mandibular full-arch bridges screw retained after 1 week to four to five Monotype implants: 3-year results from a prospective multicentre study." Clinical Oral Implants Research 19(7): 693-703.	No risk factor analysis
Astrand, P., B. Engquist, et al. (2004). "Astra Tech and Branemark system implants: a 5-year prospective study of marginal bone reactions." Clinical Oral Implants Research 15(4): 413-20.	Primary outcome was bone loss
Bedrossian, E., B. Rangert, et al. (2006). "Immediate function with the zygomatic implant: a graftless solution for the patient with mild to advanced atrophy of the maxilla." International Journal of Oral and Maxillofacial Implants 21(6): 937-42.	No risk factor analysis
Bell, B. M. and R. E. Bell (2008). "Oral bisphosphonates and dental implants: a retrospective study." Journal of Oral & Maxillofacial Surgery 66(5): 1022-4.	Bisphosphonates
Bianchi, A. E. and F. Sanfilippo (2004). "Single-tooth replacement by immediate implant and connective tissue graft: a 1-9-year clinical evaluation." Clinical Oral Implants Research 15(3): 269-77.	No risk factor analysis
Blanco, J., A. Alonso, et al. (2005). "Long-term results and survival rate of implants treated with guided bone regeneration: a 5-year case series prospective study." Clinical Oral Implants Research 16(3): 294-301.	No risk factor analysis
Blanes, R. J., J. P. Bernard, et al. (2007). "A 10-year prospective study of ITI dental implants placed in the posterior region. I: Clinical and radiographic results." Clinical Oral Implants Research 18(6): 699-706.	Survival only
Buser, D., M. M. Bornstein, et al. (2008). "Early implant placement with simultaneous guided bone regeneration following single-tooth extraction in the esthetic zone: a cross-sectional, retrospective study in 45 subjects with a 2- to 4-year follow-up." Journal of Periodontology 79(9): 1773-81.	Wrong exposure
Chou, C.-T., H. F. Morris, et al. (2004). "AICRG, Part II: Crestal bone loss associated with the Ankylos implant: loading to 36 months." Journal of Oral Implantology 30(3): 134-43.	Wrong outcome (crestal bone loss)
Chuang, S. (2005). "Jawbone, quality, jaw shape, implant length, and overdenture treatment protocol were associated with implant failures." Journal of Evidence Based Dental Practice 5(4): 215-6.	Appraisal of Herrmann 2005
Chuang, S. K. and T. Cai (2006). "Predicting clustered dental implant survival using frailty methods." Journal of Dental Research 85(12): 1147-51.	Reanalysis of Chuang 2002
Chuang, S. K., T. Cai, et al. (2005). "Frailty approach for the analysis of clustered failure time observations in dental research." Journal of Dental Research 84(1): 54-8.	Reanalysis of Chuang 2002

Chung, D. M., T.-J. Oh, et al. (2006). "Significance of keratinized mucosa in maintenance of dental implants with different surfaces." Journal of Periodontology 77(8): 1410-20.	No outcomes of interest
Chung, D. M., T.-J. Oh, et al. (2007). "Factors affecting late implant bone loss: a retrospective analysis." International Journal of Oral & Maxillofacial Implants 22(1): 117-26.	Wrong outcome (bone loss)
Cordaro, L., F. Torsello, et al. (2006). "Retrospective evaluation of mandibular incisor replacement with narrow neck implants." Clinical Oral Implants Research 17(6): 730-5.	No risk factor analysis
Cornelini, R., C. Rubini, et al. (2003). "Transforming growth factor-beta 1 expression in the peri-implant soft tissues of healthy and failing dental implants." Journal of Periodontology 74(4): 446-50.	No risk factor analysis
Cornelini, R., F. Cangini, et al. (2005). "Immediate restoration of implants placed into fresh extraction sockets for single-tooth replacement: a prospective clinical study." International Journal of Periodontics & Restorative Dentistry 25(5): 438-47.	No risk factor analysis
Coulthard, P., M. Esposito, et al. (2007). "Interventions for replacing missing teeth: surgical techniques for placing dental implants." Cochrane Database of Systematic Reviews 4.	Withdrawn from Cochrane library
Coulthard, P., M. Esposito, et al. (2007). "Interventions for replacing missing teeth: hyperbaric oxygen therapy for irradiated patients who require dental implants." Cochrane Database of Systematic Reviews 4.	No risk factors
Covani, U., A. Barone, et al. (2006). "Clinical outcome of implants placed immediately after implant removal." Journal of Periodontology 77(4): 722-7.	Wrong exposure (timing of placement)
Covani, U., R. Crespi, et al. (2004). "Immediate implants supporting single crown restoration: A 4-year prospective study." Journal of Periodontology 75(7): 982-988.	Wrong exposure (timing of placement)
Cune, M. S., J. W. Verhoeven, et al. (2004). "A prospective evaluation of Frialoc implants with ball-abutments in the edentulous mandible: 1-year results." Clinical Oral Implants Research 15(2): 167-73.	Overdentures
das Neves, F. D., D. Fones, et al. (2006). "Short implants--an analysis of longitudinal studies." International Journal of Oral and Maxillofacial Implants 21(1): 86-93.	Risks dealt with narratively Short implants
Davarpanah, M., M. Caraman, et al. (2007). "Prosthetic success with a maxillary immediate-loading protocol in the multiple-risk patient." International Journal of Periodontics & Restorative Dentistry 27(2): 161-9.	Case reports
De Backer, H., G. Van Maele, et al. (2007). "The influence of gender and age on fixed prosthetic restoration longevity: an up to 18- to 20-year follow-up in an undergraduate clinic." International Journal of Prosthodontics 20(6): 579-86.	Cannot tell if implants used or not
De Rouck, T., K. Collys, et al. (2008). "Immediate single-tooth implants in the anterior maxilla: a 1-year case cohort study on hard and soft tissue response." Journal of Clinical Periodontology 35(7): 649-57.	No risk factor analysis
Degidi, M. and A. Piattelli (2005). "Comparative analysis study of 702 dental implants subjected to immediate functional loading and immediate non-functional loading to traditional healing periods with a follow-up of up to 24 months.[see comment][erratum appears in Int J Oral Maxillofac Implants. 2005 Mar-Apr;20(2):306]." International Journal of Oral & Maxillofacial Implants 20(1): 99-107.	Effect of timing of loading
Degidi, M., A. Piattelli, et al. (2007). "Do longer implants improve clinical outcome in immediate loading?" International Journal of Oral & Maxillofacial Surgery 36(12): 1172-6.	Wrong exposure (implant length)
Del Fabbro, M., T. Testori, et al. (2006). "Systematic review of survival rates for immediately loaded dental implants." International Journal of Periodontics & Restorative Dentistry 26(3):	Only risks looked at was implant surface & timing of

249-63.	loading
DeLuca, S. and G. Zarb (2006). "The effect of smoking on osseointegrated dental implants. Part II: peri-implant bone loss." International Journal of Prosthodontics 19(6): 560-6.	Wrong outcome (peri-implant bone loss)
Dijakiewicz, M., A. Wojtowicz, et al. (2007). "Is implanto-prosthodontic treatment available for haemodialysis patients? [2]." Nephrology Dialysis Transplantation 22(9): 2722-2724.	Letter
Dos Santos, M. C. L. G., M. I. G. Campos, et al. (2004). "Analysis of the transforming growth factor-beta 1 gene promoter polymorphisms in early osseointegrated implant failure." Implant Dentistry 13(3): 262-9.	Wrong exposure (gene polymorphism)
Durham, T. M., T. King, et al. (2006). "Dental implants in edentulous adults with cognitive disabilities: report of a pilot project." Special Care in Dentistry 26(1): 40-6.	No risk factors
Duskova, M., M. Kotova, et al. (2004). "Reconstruction of maxilla alveolus for application of dental implant in patients with cleft defect." Acta Chirurgiae Plasticae 46(4): 115-121.	Wrong population
Eliasson, A., T. Eriksson, et al. (2006). "Fixed partial prostheses supported by 2 or 3 implants: a retrospective study up to 18 years." International Journal of Oral and Maxillofacial Implants 21(4): 567-74.	Focus on prosthesis survival
Ellis, I. E. and D. McFadden (2007). "The Value of a Diagnostic Setup for Full Fixed Maxillary Implant Prosthetics." Journal of Oral and Maxillofacial Surgery 65(9): 1764-1771.	Not concerning risk factors for implant loss
Erdogan, O., D. M. Shafer, et al. (2007). "A review of the association between osteoporosis and alveolar ridge augmentation." Oral Surgery Oral Medicine Oral Pathology Oral Radiology & Endodontics 104(6): 738.e1-13.	Wrong outcomes
Esposito, M. A. B., A. Koukoulopoulou, et al. (2006). "Interventions for replacing missing teeth: dental implants in fresh extraction sockets (immediate, immediate-delayed and delayed implants)." Cochrane Database of Systematic Reviews(4): CD005968.	Timing of implant
Esposito, M., H. V. Worthington, et al. (2005). "Interventions for replacing missing teeth: dental implants in zygomatic bone for the rehabilitation of the severely deficient edentulous maxilla.[update of Cochrane Database Syst Rev. 2003;(3):CD004151; PMID: 12918005]." Cochrane Database of Systematic Reviews(4): CD004151.	Not relevant to guideline
Esposito, M., L. Murray-Curtis, et al. (2007). "Interventions for replacing missing teeth: different types of dental implants." Cochrane Database of Systematic Reviews(4): CD003815.	Types of implants
Esposito, M., M. G. Grusovin, et al. (2006). "Interventions for replacing missing teeth: treatment of perimplantitis.[update of Cochrane Database Syst Rev. 2004;(4):CD004970; PMID: 15495132]." Cochrane Database of Systematic Reviews 3: CD004970.	Treatment
Esposito, M., M. G. Grusovin, et al. (2006). "Interventions for replacing missing teeth: bone augmentation techniques for dental implant treatment.[update of Cochrane Database Syst Rev. 2003;(3):CD003607; PMID: 12917975]." Cochrane Database of Systematic Reviews(1): CD003607.	Updated by Esposito 2008[3]
Esposito, M., M. G. Grusovin, et al. (2007). "Interventions for replacing missing teeth: different times for loading dental implants.[update of Cochrane Database Syst Rev. 2004;(3):CD003878; PMID: 15266505]." Cochrane Database of Systematic Reviews(2): CD003878.	Timing of loading
Esposito, M., M. Grusovin, et al. (2008). "Interventions for replacing missing teeth: hyperbaric oxygen therapy for irradiated patients who require dental implants [Systematic Review]." Cochrane Database of Systematic Reviews 3.	Treatment
Fardal, O. and G. J. Linden (2008). "Tooth loss and implant outcomes in patients refractory to	No risk analysis

treatment in a periodontal practice." Journal of Clinical Periodontology 35(8): 733-8.	
Feldman, S., N. Boitel, et al. (2004). "Five-year survival distributions of short-length (10 mm or less) machined-surfaced and Osseotite implants." Clinical Implant Dentistry & Related Research 6(1): 16-23.	No risk factor analysis
Ferrara, A., C. Galli, et al. (2006). "Immediate provisional restoration of postextraction implants for maxillary single-tooth replacement." International Journal of Periodontics & Restorative Dentistry 26(4): 371-7.	Immediate placement
Ferreira, S. D., G. L. M. Silva, et al. (2006). "Prevalence and risk variables for peri-implant disease in Brazilian subjects." Journal of Clinical Periodontology 33(12): 929-35.	Wrong outcomes
Finnema, K. J., G. M. Raghoebar, et al. (2005). "Oral rehabilitation with dental implants in oligodontia patients." International Journal of Prosthodontics 18(3): 203-9.	Wrong population
Fischer, K. and T. Stenberg (2006). "Three-year data from a randomized, controlled study of early loading of single-stage dental implants supporting maxillary full-arch prostheses." International Journal of Oral & Maxillofacial Implants 21(2): 245-52.	No risk factor
Fugazzotto, P. A., J. R. Beagle, et al. (2004). "Success and failure rates of 9 mm of shorter implants in the replacement of missing maxillary molars when restored with individual crowns: Preliminary results 0 to 84 months in function. A retrospective study." Journal of Periodontology 75(2): 327-332.	No risk factor
Garfinkle, J. S., L. L. Cunningham, Jr., et al. (2008). "Evaluation of orthodontic mini-implant anchorage in premolar extraction therapy in adolescents." American Journal of Orthodontics & Dentofacial Orthopedics 133(5): 642-53.	Orthodontic anchorage
Gotfredsen, K. (2004). "A 5-year prospective study of single-tooth replacements supported by the Astra Tech implant: a pilot study." Clinical Implant Dentistry & Related Research 6(1): 1-8.	No risk factor
Iqbal, M. K. and S. Kim (2008). "A review of factors influencing treatment planning decisions of single-tooth implants versus preserving natural teeth with nonsurgical endodontic therapy." Journal of Endodontics **34**(5): 519-29.	Treatment planning
Hagi, D., D. A. Deporter, et al. (2004). "A targeted review of study outcomes with short (< or = 7 mm) endosseous dental implants placed in partially edentulous patients." Journal of Periodontology 75(6): 798-804.	Could not calculate risk of failure
Henry, P. J., D. van Steenberghe, et al. (2003). "Prospective multicenter study on immediate rehabilitation of edentulous lower jaws according to the Branemark Novum protocol." Clinical Implant Dentistry & Related Research 5(3): 137-42.	Fixed complete prosthesis
Herrmann, I., U. Lekholm, et al. (2005). "Evaluation of patient and implant characteristics as potential prognostic factors for oral implant failures.[see comment]." International Journal of Oral & Maxillofacial Implants 20(2): 220-30.	Already in previous review
Herzberg, R., E. Dolev, et al. (2006). "Implant marginal bone loss in maxillary sinus grafts." International Journal of Oral & Maxillofacial Implants 21(1): 103-10.	Wrong outcome
Hirsch, J.-M., L.-O. Ohrnell, et al. (2004). "A clinical evaluation of the Zygoma fixture: one year of follow-up at 16 clinics." Journal of Oral & Maxillofacial Surgery 62(9 Suppl 2): 22-9.	Zygomatic implants
Horwitz, J., O. Zuabi, et al. (2007). "Immediate and delayed restoration of dental implants in periodontally susceptible patients: 1-year results." International Journal of Oral & Maxillofacial Implants 22(3): 423-9.	Timing of restoration
Hug, S., D. Mantokoudis, et al. (2006). "Clinical evaluation of 3 overdenture concepts with tooth roots and implants: 2-year results." International Journal of Prosthodontics 19(3): 236-43.	Overdentures

Ioannidou, E. and A. Doufexi (2005). "Does loading time affect implant survival? A meta-analysis of 1,266 implants." Journal of Periodontology 76(8): 1252-8.	No risk factors
Jemt, T. and P. Hager (2006). "Early complete failures of fixed implant-supported prostheses in the edentulous maxilla: a 3-year analysis of 17 consecutive cluster failure patients." Clinical Implant Dentistry & Related Research 8(2): 77-86.	Fixed complete prostheses
Jemt, T., G. Ahlberg, et al. (2007). "Tooth movements adjacent to single-implant restorations after more than 15 years of follow-up." International Journal of Prosthodontics 20(6): 626-32.	Wrong outcome
Johansson, L. and A. Ekfeldt (2003). "Implant-supported fixed partial prostheses: a retrospective study." International Journal of Prosthodontics 16(2): 172-6.	No risk factor analysis
Jung, R. E., B. E. Pjetursson, et al. (2008). "A systematic review of the 5-year survival and complication rates of implant-supported single crowns." Clinical Oral Implants Research 19(2): 119-30.	Survival only
Jungner, M., P. Lundqvist, et al. (2005). "Oxidized titanium implants (Nobel Biocare TiUnite) compared with turned titanium implants (Nobel Biocare mark III) with respect to implant failure in a group of consecutive patients treated with early functional loading and two-stage protocol." Clinical Oral Implants Research 16(3): 308-12.	No risk factor analysis
Kahnberg, K.-E., P. J. Henry, et al. (2007). "Clinical evaluation of the zygoma implant: 3-year follow-up at 16 clinics." Journal of Oral & Maxillofacial Surgery 65(10): 2033-8.	No risk factor analysis
Kan, J. Y. K., K. Rungcharassaeng, et al. (2003). "Immediate placement and provisionalization of maxillary anterior single implants: 1-year prospective study." International Journal of Oral and Maxillofacial Implants 18(1): 31-9.	Timing of placement
Karoussis, I. K., G. E. Salvi, et al. (2003). "Long-term implant prognosis in patients with and without a history of chronic periodontitis: a 10-year prospective cohort study of the ITI Dental Implant System." Clinical Oral Implants Research 14(3): 329-39.	Included in Schou (2006)[50] systematic review
Karoussis, I. K., S. Muller, et al. (2004). "Association between periodontal and peri-implant conditions: a 10-year prospective study." Clinical Oral Implants Research 15(1): 1-7.	Wrong outcomes
Karoussis, I. K., U. Bragger, et al. (2004). "Effect of implant design on survival and success rates of titanium oral implants: a 10-year prospective cohort study of the ITI Dental Implant System." Clinical Oral Implants Research 15(1): 8-17.	Wrong exposure (implant design)
Kim, D. M., R. L. Badovinac, et al. (2008). "A 10-year prospective clinical and radiographic study of one-stage dental implants." Clinical Oral Implants Research 19(3): 254-8.	Wrong outcome
Knauf, M., T. Gerds, et al. (2007). "Survival and success rates of 3i implants in partially edentulous patients: results of a prospective study with up to 84-months' follow-up." Quintessence International 38(8): 643-51.	No risk factors
Kramer, F. J., C. Baethge, et al. (2005). "Dental implants in patients with orofacial clefts: a long-term follow-up study." International Journal of Oral & Maxillofacial Surgery 34(7): 715-21.	Wrong population (orofacial clefts)
Lang, N. P., T. Berglundh, et al. (2004). "Consensus statements and recommended clinical procedures regarding implant survival and complications." International Journal of Oral & Maxillofacial Implants 19 Suppl: 150-4.	Wrong outcomes
Laster, Z. and O. T. Jensen (2008). "Secondarily stabilized dental implants: an alternative to sinus grafting--early clinical results of 63 consecutively placed implants." Journal of Oral & Maxillofacial Surgery 66(10): 2136-9.	Surgical technique
Leung, A. C. F. and L. K. Cheung (2003). "Dental implants in reconstructed jaws: patients' evaluation of functional and quality-of-life outcomes." International Journal of Oral and	No risk factor analysis

Maxillofacial Implants 18(1): 127-34.	
Lin, Y.-H., P. Huang, et al. (2007). "The relationship between IL-1 gene polymorphism and marginal bone loss around dental implants." Journal of Oral & Maxillofacial Surgery 65(11): 2340-4.	Wrong outcome
Lindh, T. (2008). "Should we extract teeth to avoid tooth-implant combinations?" Journal of Oral Rehabilitation 35 Suppl 1: 44-54.	No risk factor analysis Narrative review
Lundgren, D., H. Rylander, et al. (2008). "To save or to extract, that is the question. Natural teeth or dental implants in periodontitis-susceptible patients: clinical decision-making and treatment strategies exemplified with patient case presentations." Periodontology 2000 47: 27-50.	Case reports
Martinez Iturriaga, M. T. and C. Colmenero Ruiz (2004). "Maxillary Sinus Reconstruction with Calvarium Bone Grafts and Endosseous Implants." Journal of Oral and Maxillofacial Surgery 62(3): 344-347.	No risk factors
Meijer, H. J. A., G. M. Raghoebar, et al. (2003). "Comparison of implant-retained mandibular overdentures and conventional complete dentures: a 10-year prospective study of clinical aspects and patient satisfaction." International Journal of Oral & Maxillofacial Implants 18(6): 879-85.	Overdenture
Merli, M., F. Bernardelli, et al. (2008). "Immediate versus early nonocclusal loading of dental implants placed with a flapless procedure in partially edentulous patients: preliminary results from a randomized controlled clinical trial." International Journal of Periodontics & Restorative Dentistry 28(5): 453-9.	Wrong exposure (timing of loading)
Mesa F, Munoz R, Noguerol B, de Dios Luna J, Galindo P, O'Valle F. Multivariate study of factors influencing primary dental implant stability. Clinical Oral Implants Research 2008;19(2):196-200.	Wrong outcome (implant stability)
Miyamoto, Y., K. Fujisawa, et al. (2003). "Effect of the additional installation of implants in the posterior region on the prognosis of treatment in the edentulous mandibular jaw." Clinical Oral Implants Research 14(6): 727-33.	Wrong exposure
Molly, L. (2006). "Bone density and primary stability in implant therapy." Clinical Oral Implants Research 17 Suppl 2: 124-35.	No risk analysis
Moradi, D. R., P. K. Moy, et al. (2006). "Evidence-based research in alternative protocols to dental implantology: a closer look at publication bias." Journal of the California Dental Association 34(11): 877-86.	Wrong exposure
Morris, H. F., S. Ochi, et al. (2004). "AICRG, Part V: Factors influencing implant stability at placement and their influence on survival of Ankylos implants." Journal of Oral Implantology 30(3): 162-70.	Wrong outcome
Nakai, H., Y. Okazaki, et al. (2003). "Clinical application of zygomatic implants for rehabilitation of the severely resorbed maxilla: a clinical report." International Journal of Oral and Maxillofacial Implants 18(4): 566-70.	Zygomatic implants
Nedir, R., M. Bischof, et al. (2004). "A 7-year life table analysis from a prospective study on ITI implants with special emphasis on the use of short implants. Results from a private practice." Clinical Oral Implants Research 15(2): 150-7.	No risk factors
Nedir, R., M. Bischof, et al. (2006). "Prosthetic complications with dental implants: from an up-to-8-year experience in private practice." International Journal of Oral and Maxillofacial Implants 21(6): 919-28.	Wrong outcomes

Nentwig, G. H. (2004). "Ankylos implant system: concept and clinical application." Journal of Oral Implantology 30(3): 171-7.	No risk factor analysis
Nickenig, H.-J., H. Spiekermann, et al. (2008). "Survival and complication rates of combined tooth-implant-supported fixed and removable partial dentures." International Journal of Prosthodontics 21(2): 131-7.	Wrong outcomes
Nkenke, E. and M. Fenner (2006). "Indications for immediate loading of implants and implant success." Clinical Oral Implants Research 17 Suppl 2: 19-34.	Timing of loading
Ormianer, Z. and A. Palti (2006). "Long-term clinical evaluation of tapered multi-threaded implants: results and influences of potential risk factors." Journal of Oral Implantology 32(6): 300-7.	No outcomes of interest
Ostman, P.-O. (2008). "Immediate/early loading of dental implants. Clinical documentation and presentation of a treatment concept." Periodontology 2000 47: 90-112.	Timing of loading
Ottoni JMP, Oliveira ZFL, Mansini R, Cabral AM. Correlation between placement torque and survival of single-tooth implants. International Journal of Oral & Maxillofacial Implants 2005;20(5):769-76.	No outcomes of interest
Park W, Kim HS. Osteoma of maxillary sinus: a case report. Oral Surgery Oral Medicine Oral Pathology Oral Radiology & Endodontics 2006;102(6):e26-7.	Case report
Paton, G., J. Fuss, et al. (2002). "The transmandibular implant: a 5- and 15-year single-center study." Journal of Oral and Maxillofacial Surgery 60(8): 851-7.	Transmandibular implant
Payne, A. G. T., A. Tawse-Smith, et al. (2003). "Early functional loading of unsplinted roughened surface implants with mandibular overdentures 2 weeks after surgery." Clinical Implant Dentistry & Related Research 5(3): 143-53.	Overdentures
Payne, A. G. T., A. Tawse-Smith, et al. (2004). "One-stage surgery and early loading of three implants for maxillary overdentures: a 1-year report." Clinical Implant Dentistry & Related Research 6(2): 61-74.	Overdentures
Peled, M., L. Ardekian, et al. (2003). "Dental implants in patients with type 2 diabetes mellitus: a clinical study." Implant Dentistry 12(2): 116-22.	No risk factors
Pinholt, E. M. (2003). "Branemark and ITI dental implants in the human bone-grafted maxilla: a comparative evaluation." Clinical Oral Implants Research 14(5): 584-92.	No risk factor analysis
Polo, W. C. K., N. S. de Araujo, et al. (2007). "Peri-implant bone loss around posterior mandible dental implants placed after distraction osteogenesis: preliminary findings." Journal of Periodontology 78(2): 204-8.	Wrong outcome
Quirynen, M., R. Vogels, et al. (2005). "Predisposing conditions for retrograde peri-implantitis, and treatment suggestions." Clinical Oral Implants Research 16(5): 599-608.	Wrong outcome
Rao, N., Y. Cao, et al. (2006). "Investigation of peri-implant status and risk variables for implant failure in body of maxilla after oral tumor surgery." Journal of Huazhong University of Science and Technology Medical Sciences 26(6): 756-8.	Wrong population
Renouard, F. and D. Nisand (2006). "Impact of implant length and diameter on survival rates." Clinical Oral Implants Research 17 Suppl 2: 35-51.	Wrong exposures
Romeo, E., D. Lops, et al. (2003). "Implant-supported fixed cantilever prostheses in partially edentulous arches. A seven-year prospective study." Clinical Oral Implants Research 14(3): 303-11.	No risk factor analysis
Sadowsky, S. J. (2007). "Treatment considerations for maxillary implant overdentures: a systematic review." Journal of Prosthetic Dentistry 97(6): 340-8.	Overdentures

Santos, M. C. L. and M. I. G. Campos (2004). "Analysis of MMP-1 and MMP-9 promoter polymorphisms in early osseointegrated implant failure." International Journal of Oral and Maxillofacial Implants 19(1): 38-43.	Polymorphism
Schepers, R. H., A. P. Slagter, et al. (2006). "Effect of postoperative radiotherapy on the functional result of implants placed during ablative surgery for oral cancer." International Journal of Oral and Maxillofacial Surgery 35(9): 803-808.	Wrong population
Schleier, P., G. Bierfreund, et al. (2008). "Simultaneous dental implant placement and endoscope-guided internal sinus floor elevation: 2-year post-loading outcomes." Clinical Oral Implants Research 19(11): 1163-70.	Surgical technique
Schoen, P. J., G. M. Raghoebar, et al. (2007). "Rehabilitation of oral function in head and neck cancer patients after radiotherapy with implant-retained dentures: effects of hyperbaric oxygen therapy." Oral Oncology 43(4): 379-88.	Treatment
Schropp, L. and F. Isidor (2008). "Clinical outcome and patient satisfaction following full-flap elevation for early and delayed placement of single-tooth implants: a 5-year randomized study." International Journal of Oral & Maxillofacial Implants 23(4): 733-43.	Timing of implant placement
Schropp, L. and F. Isidor (2008). "Timing of implant placement relative to tooth extraction." Journal of Oral Rehabilitation 35 Suppl 1: 33-43.	Timing of implant placement
Schropp, L., L. Kostopoulos, et al. (2005). "Clinical and radiographic performance of delayed-immediate single-tooth implant placement associated with peri-implant bone defects. A 2-year prospective, controlled, randomized follow-up report." Journal of Clinical Periodontology 32(5): 480-7.	Timing of implant placement
Sennerby, L., A. Rocci, et al. (2008). "Short-term clinical results of Nobel Direct implants: a retrospective multicentre analysis." Clinical Oral Implants Research 19(3): 219-26.	No risk factors
Shimpuku, H., Y. Nosaka, et al. (2003). "Genetic polymorphisms of the interleukin-1 gene and early marginal bone loss around endosseous dental implants." Clinical Oral Implants Research 14(4): 423-9.	Wrong exposure and outcome
Shin, S.-W., S. R. Bryant, et al. (2004). "A retrospective study on the treatment outcome of wide-bodied implants." International Journal of Prosthodontics 17(1): 52-8.	No patient-related risk factors
Slagter, K. W., G. M. Raghoebar, et al. (2008). "Osteoporosis and edentulous jaws." International Journal of Prosthodontics 21(1): 19-26.	Only four studies in this systematic review relevant – 2 were already included in the previous 2004 review[1]; one was excluded[60]; the remaining one was retrieved (Holahan 2008[11])
Stricker, A., R. Gutwald, et al. (2004). "Immediate loading of 2 interforaminal dental implants supporting an overdenture: clinical and radiographic results after 24 months." International Journal of Oral & Maxillofacial Implants 19(6): 868-72.	Overdenture
Teoh, K. H., J. M. Huryn, et al. (2005). "Implant prosthodontic rehabilitation of fibula free-flap reconstructed mandibles: a Memorial Sloan-Kettering Cancer Center review of prognostic factors and implant outcomes." International Journal of Oral & Maxillofacial Implants 20(5): 738-46.	Wrong population
Trakas, T., K. Michalakis, et al. (2006). "Attachment systems for implant retained overdentures: a literature review." Implant Dentistry 15(1): 24-34.	Overdentures
Turkyilmaz, I., M. Avci, et al. (2007). "A 4-year prospective clinical and radiological study of maxillary dental implants supporting single-tooth crowns using early and delayed loading	Loading protocol

protocols." Clinical Implant Dentistry & Related Research 9(4): 222-7.	
Van der Weijden, G. A., K. M. van Bemmel, et al. (2005). "Implant therapy in partially edentulous, periodontally compromised patients: a review." Journal of Clinical Periodontology 32(5): 506-11.	Superseded by Schou 2006[50]
Visser, A., G. M. Raghoebar, et al. (2005). "Mandibular overdentures supported by two or four endosseous implants. A 5-year prospective study." Clinical Oral Implants Research 16(1): 19-25.	Overdentures
Visser, A., H. J. A. Meijer, et al. (2006). "Implant-retained mandibular overdentures versus conventional dentures: 10 years of care and aftercare." International Journal of Prosthodontics 19(3): 271-8.	Overdentures
Watzak, G., W. Zechner, et al. (2006). "Radiological and clinical follow-up of machined- and anodized-surface implants after mean functional loading for 33 months." Clinical Oral Implants Research 17(6): 651-7.	Wrong outcomes
Weng, D. and E.-J. Richter (2007). "Maxillary removable prostheses retained by telescopic crowns on two implants or two canines." International Journal of Periodontics & Restorative Dentistry 27(1): 35-41.	Survival of dentures
Wennstrom, J. L., A. Ekestubbe, et al. (2005). "Implant-supported single-tooth restorations: a 5-year prospective study." Journal of Clinical Periodontology 32(6): 567-74.	No risk factor analysis
Yerit, K. C., M. Posch, et al. (2004). "Long-term implant survival in the grafted maxilla: results of a 12-year retrospective study." Clinical Oral Implants Research 15(6): 693-9.	Wrong exposure (1 or 2 stage procedure)
Zollner, A., J. Ganeles, et al. (2008). "Immediate and early non-occlusal loading of Straumann implants with a chemically modified surface (SLActive) in the posterior mandible and maxilla: interim results from a prospective multicenter randomized-controlled study." Clinical Oral Implants Research 19(5): 442-50.	No risk factor analysis