Dental Implants: Patient Selection, Patient Satisfaction and Cost Factors

Evidence Based Review

Peter Larking, ACC

Referees – Jonathan Leichter and Karl Lyons, University of Otago, School of Dentistry

Table of Contents

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Reviewers	Peter Larking BSc(Hons) PhD
Referees	Jonathan Leichter, D.M.D., Karl Lyons. BDS, MS; University of Otago, School of Dentistry
Literature Search	Mai Dwairy and Amanda Bowens
Date of Final Draft	18 May 2004

Important Notes:

- This evidence based review summarises information on dental implants. It is not intended to replace clinical judgement, or be used as a clinical protocol.
- 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.
- The report was subject to the review of independent referees. Their comments are shown throughout the document in italics and their references listed separately.

Summary

An evidence based review of the literature has been conducted to investigate factors effecting the selection of patients for dental implants, patient satisfaction with implant systems and cost of dental implants as the prelude to the development of a guideline. Literature searching was restricted to greater than 1995 for patient selection and cost studies, in order to restrict the volume of literature to a manageable size; and from 1998 for patient satisfaction, as in this year a major systematic review on this topic was published. Seventy papers were reviewed. The design quality of these papers was relatively poor, especially for patient selection factors and in consequence, guideline

development will have to rely on a mix of existing evidence, expert opinion and consensus development.
The main findings of the review are:-

1. Dental implants are a successful interventions that typically have success rates of greater than 90% over the longer term, in university settings

2. In uncomplicated situations the following factors are unlikely to significantly increase the clinical risk of implant failure: smoking, well controlled Type 2 Diabetes, osteoporosis, post menopausal status, well controlled hypothyroidism, well controlled cardiovascular disease and age of adults

3. In totally edentulous arches, differences in implant failure rates between the maxilla and the mandible may be of clinical significance
4. Differences in implant failure rates between partially and completely edentulous jaws may not be of clinical relevance
5. In bounded edentulous spaces, there is an indication that teeth adjacent to an implant have a very low rate of complication, but not providing a restoration, does not usually result in significant loss of adjacent teeth either

6. Patient selection factors for dental implants that require the careful exercise of clinical judgement are bruxism and other parafunctional activities, and dental implants at grafted sites

7. Expert opinion and consensus development may be required if criteria for patient selection are to be established for the following factors; bone quality and volume, current infection, periodontitis, poor oral hygiene and uncontrolled caries

8. Implant systems may be the treatment of choice in patients with severely resorbed mandibles

9. Implant supported dentures in the mandible provide some degree of increased patient satisfaction over that obtained with conventional dentures

10. Dental implants located after maxillary sinus augmentation have increased rates of failure that is likely to be of clinical significance

11. Implant supported prostheses in the maxilla should not be considered the treatment of choice in patients with sufficient bony support for conventional prostheses

12. There is an indication in the literature that for patients with a bounded edentulous space, satisfaction with resin bonded prostheses is similar to implant supported prostheses

13. Conventional dentures in the mandible and resin bonded dentures in bounded edentulous spaces, are much cheaper than implant retained systems
14. In uncomplicated situations, it is proposed that an implant-retained system is not an appropriate first line of intervention for tooth loss in either the mandible or the maxilla. In most cases a conventional denture, resin-bonded system or other similar alternative, should be trialled first.

Dental Implants

Introduction

Missing teeth have traditionally been replaced with dentures that rely on the residual alveolar ridge and mucosa for support and retention. Where there is inadequate oral anatomy to support the denture, surgery may be required (preprosthetic surgery). Complete denture wearers are usually able to wear an upper denture without problems but many struggle to eat with a lower denture because of its mobility[1].

Dental implants offer an alternative in many circumstances. Common forms of implants are inserted into the jawbone to support the denture or prosthesis. Direct structural and functional connection between the bone and the implant surface occurs to securely anchor the supported structure, a process called osseointegration. Osseointegration has been described as one of the most significant breakthroughs in dentistry over the last thirty years[2]. Success rates are generally of the order of 80% plus for the maxilla and 90% plus for the mandible[3].

The failure of an implant to osseointegrate is a relatively benign event that causes little irreversible damage[4]. Failure usually occurs soon after placement[5] and the likelihood of it decreases steadily through the first five years of surgery. According to Tonetti[6] implant failures are not randomly distributed in the population. Patients with multiple implants that have one failure, have a 30% increase in probability of a second failure.

This evidence based review was prepared for ACC Healthwise and is concerned with reviewing the literature as a first step to guideline development. According to Koele and Hoogstraten (1999)[7], there are discrepancies between what dentists say are important factors for selecting patients for dental implants and what they use as important factors. They concluded that guidelines should be developed to enable standardisation.

Objectives

The objective is to provide an evidence base for the use of dental implants concentrating on patient selection, patient satisfaction and cost factors, in preparation for the development of guidelines.

Criteria for selecting studies for this review

Types of Studies: Randomised controlled studies, systematic reviews, other guidelines, case –control and case series studies, that reported on patient selection, patient satisfaction and cost factors.

Types of Participants: Partially or completely edentulous patients. (The review was not confined to edentulousness as a result of injury).

Types of Interventions: Dental implants intended to osseointegrate and alternative technologies where a comparison was possible.

Types of Outcome Measures: Implant survival, patient selection factors, patient satisfaction and cost comparisons.

Search Strategy

The following databases were searched:-
CINAHL, Medline in Process, Medline, Medline Daily Update, EMBASE, ACP Journal Club, DARE, CDSR, CCTR, and other Evidenced based healthcare websites.
Inclusion criteria were -

- Only papers in English that included more than 9 subjects
- For patient selection and cost factors, all papers found published after 1995 were included (the rationale for setting this year was to limit the number of papers for review to a manageable number)
- For patient satisfaction factors, all papers published after 1997 and not included in the systematic review of Locker (1998)[8]. (The rationale for selecting this date was the existence of the systematic review that had assessed past literature on patient satisfaction as it relates to dental implants)
- The paper was available through standard services. At the time of writing a small number of papers, likely to be included if available, were not procurable through normal channels
- The search strategy date was 3/7/03.

Examples of typical searches are shown in Appendix A.

Methodological Quality

Reviewed papers were assigned a design score according to the following SIGN[9] criteria (Table 1).

Table 1. SIGN criteria for classifying studies.

Score	Design
1++	High quality meta-analyses, systematic review 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 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
4	Expert opinion

Results and Discussion

A total of 70 papers were reviewed. Most were of case series design or relied on case series data for analysis. Overall, especially for patient selection, the design quality of the papers was relatively poor.

Two other factors affecting the external validity of the studies reviewed were the application of strict inclusion criteria and many were conducted in university clinics. Because of this, the data may not relate well to the private clinic situation.

It is clear that dental implants can be a highly successful intervention with success rates typically greater than 90% eg[10-13]. Often though these results were obtained in University settings.

1. Patient Selection Factors

1.1. Effect of smoking

Twenty papers were reviewed that referred at least in part to the effect of smoking on implant survival, including 10 with cohort or case–control designs based on case series data, 7 case series studies, 2 surveys assessing practitioner opinion (Table 2) and one consensus guideline.
Of the case-control or cohort studies (Table 2) -

- Four found outcomes to be worse in smokers[10, 14-16] that were of statistical significance. The relative risk of failure in smokers compared to non-smokers was available or able to be calculated in 3 of these papers (RR= 1.5, 3.1, 2.5)
- Two studies[17, 18] reported differences that were thought indicative of a higher risk of failure in smokers but no statistics were presented
- Two studies[13, 19] found differences that were considered to be not significant.
- One study found that various measures of peri-implantitis were significantly worse in smokers[20]
- One study investigated the effect of smoking on implant survival in patients who had maxillary bone grafts[21]; success rates were significantly worse in smokers where about one third of implants failed.

Of the seven case series studies –

- One study[22] considered smoking to be a risk factor for implant failure but provided no statistics
- Three studies, one of which was in diabetics[23] considered smoking not to be a risk factor[23-25]
- One study considered that smoking had a deleterious effect on implant survival in patients with maxillary bone grafts[26]
- Two studies investigated the effect of smoking on bone loss around the implant; One found smoking to significantly increase bone loss[27] in patients with periodontitis; One study investigating early marginal bone loss around implants reported that smoking had no effect[28].

A smoking cessation programme[15] covering the immediate implantation period has been found to significantly improve implant survival. The Dental Implant Clinical Research

Group (DICRG) study[10] also found that use of preoperative antibiotics and use of hydroxyapatite coated implants reduced risk of failure in smokers.

Two surveys[3, 29] found that dentists in general consider smoking to be a significant factor contributing to implant failure rates; Heinikainen et al[29] reported that more than 50% of dentists would not recommend implants in patients who were heavy smokers whereas Butterworth[3] reported that in England 90% of dentists considered smoking to be an important medical factor contraindicating implantation.

A consensus statement from the Faculty of Dentistry, Royal College of Surgeons, England[30] has recommended that tobacco smokers should be counselled to quit or reduce smoking or be refused treatment especially if other risk factors are present.

Discussion

Concerns of the effect of smoking on implant survival arise from research suggesting that smoking promotes periodontal disease, effects inflammatory response and adversely effects haemodynamic parameters[31]. The evidence for a significant detrimental effect of smoking on implant survival is weak. While some studies suggest that the risk of failure can be as much as three times that of non smokers[14], findings have been inconsistent with some large studies finding no significant effect[13, 19]. Moreover the absolute increase in risk caused by smoking is quite small and implant survival in smokers typically remains high: Lambert et al[10] reported for example that the success rate in non smokers was 94% compared to 91% in smokers giving a RR of 1.5 but an absolute risk increase due to smoking of only 3%.

There are suggestions in the literature[10] that any detrimental effect of smoking can be ameliorated by the use of preoperative antibiotics or by using hydroxyapatite coated implants. Cessation of smoking from one week before to eight weeks after initial implant placement[15] also appears to be effective.

Given that the increase in absolute risk of implant failure is relatively small in smokers, it is perhaps surprising that surveys show that dentists consider smoking to be such an important contraindication[3, 29]. Smoking may be an important contraindication though when it is present together with a second risk factor such as maxillary bone grafting. Kan et al[21] found that with this combination of risk factors about one third of implants failed.

It is concluded that there is little evidence to suggest that smoking is an important risk factor in the absence of other relevant risk factors.

Suggested Recommendation	Smoking as a single risk factor may not increase the risk of implant failure sufficiently to deny treatment.

Suggested Recommendation	Dental implants may be contraindicated in smokers who have other relevant risk factors present (eg requirement for maxillary bone grafts).

Comment	Implant survival may possibly be improved in smokers by implementing smoking cessation programmes or using preoperative antibiotics.

Referees' Comments.

While heavy smoking has been shown to adversely affect the long term prognosis of dental implants [41, 42, 43, 44] (Bain and Moy 1993, Gorman et al 1994 Bain 1996 and Haas et al 1996) we agree that the body of literature supports the suggested recommendations that smoking as a single risk factor may not increase the risk of implant failure sufficiently to deny treatment and ***dental implants may be contraindicated in smokers who have other relevant risk factors present. When establishing patient selection guidelines, it will be important to identify the"other relevant" risk factors and design an algorithm that will weight each factor accordingly, to arrive at a threshold for patient suitability for implant therapy.***

It seems likely that implant survival may be increased in smokers by implementing smoking cessation programmes. There is conflicting and scanty data available as to the appropriate length of time that would be required to elicit a positive effect on implant outcomes with studies having a range of 1 to 8 weeks of smoking cessation. If this recommendation was adopted as a guideline for patient selection, we would be relying on patient self-reporting, which is notoriously unreliable.

The literature does not support the recommendation that implant survival may be improved by using preoperative antibiotics or using hydroxyapatite coated implants. In a review articles by Steineman and one by Ellingsen [40] in Periodontology 2000 Vol 17, 1998 the clear conclusion is that a titanium interface with bone is the undisputed material of choice.

Administration of antibiotics remains controversial and its application should defer to clinical judgment on a case-by case basis.

Table 2. Effect of smoking on failure of dental implants

Reference	Design Score	Intervention	Total number of implants	Key Results
Butterworth CJ, Baxter AM, Shaw MJ, Bradnock G. 2001[3]	4	Dental implantation (70% Branemark) Survey of risk factors		90% of respondents thought that smoking was an important medical factor contraindicating implantation.
Lambert PM, Morris HF, Ochi S 2000[10]	2+	Dental implants. Effect of smoking on implant failure.	2887	RR of implant failure for smokers/non-smokers was 1.5 (95% CI, 1.3 - 1.95). Smoking was a variable significantly related to implant failure (p=0.0037). Hydroxyapaptite coated implants appeared to reduce the risk of implant failure particularly in smokers. The use of pre-operative antibiotics reduced failures in both groups and appeared to eliminate the negative effect of smoking. Cessation of smoking appeared to also reduce risk. No statistics are presented for much of the data.
Bain CA, Weng D, Meltzer A, Kohles SS, Stach RM. 2002[13]	2+	Patients receiving Osseotite implants (dual acid etched) or machine surfaced 3i implants. Implant survival in smokers v. non-smokers.	4888	Smoking appeared to have no clinical effect on implant failure rate.
Chuang SK, Wei LJ, Douglass CW, Dodson TB. 2002[14]	2+	Dental implant (Bicon) survival and factors related to this. Analysis allowed for clustering of failure and accounted for various time frames from	2349	Based on the adjusted multivariate model, current tobacco use was associated with implant failure (Hazard Ratio = 3.1, 95% CI 1.7-5.5, p<0.01).

Table 2. Effect of smoking on failure of dental implants				
Reference	**Design Score**	**Intervention**	**Total number of implants**	**Key Results**
		implantation.		
Bain CA. 1996[15]	2-	Dental implantation in smokers and non smokers - effect of a smoking cessation protocol that required no smoking 1 week before implantation to 8 weeks after.	223	Patients were classified into one of three groups; non smokers (NS), those who smoked through the period 1 week before till 8 weeks after initial placement (S) and those who observed a cessation protocol over this period (CS). Failure rates in the 3 groups NS, CS and S were respectively 5.68%, 11.76% and 38.46%. The difference in outcome between the NS and S groups was significant ($p<0.005$) as was the difference between the CS and S groups ($P<0.05$). There was no significant difference between the NS and CS groups. Bain concluded that a smoking cessation protocol showed promise in improving implant outcome in smokers.
Wilson TG, Jr., Nunn M 1999[16]	2-	Relation of interleukin -1 genotype to implant (Branemark and Straumann) failure. The kit used to identify genotype status is referenced but not described.	101	Smoking increased risk of implant loss compared to non-smokers (RR = 2.5, (95% CI, 1.13-5.55), P = 0.024).
Ekfeldt A, Christiansson U, Eriksson T, et al 2001[17]	2-	A fixed prosthesis or an overdenture supported by at least 4 implants (Branemark System) in the maxilla. Factors associated with multiple implant failure.	301	Factors thought likely to contribute to multiple implant failure included smoking. No statistics were presented.
Elsubeihi and Zarb 2002[18]	2-	Dental implants, effect of smoking on implant failure.	1539	The relative risk (RR) of failure in those who smoked during the initial healing phase was 1.69 times that of those who did not smoke. In patients with a smoking history of 25 years of more the risk of late implant failure was 1.91 that of those who did not smoke.
Minsk L, Polson AM, Weisgold A, et al. 1996[19]	2+	Dental implants, (70% Branemark), factors effecting implant failure.	1263	RR for failure in smokers compared to non-smokers was 1.19 (95% CI 0.71-1.99).
Haas R, Haimbock W, Mailath G, Watzek G 1996[20]	2+	Peri-implantitis in smokers and non-smokers with dental implants (Branemark and IMZ).	1366	In the maxilla, bleeding index, rate of peri-implant mucosal inflammation, mean peri-implant pocket depth and radiographically determined bone resorption were significantly worse in the smokers ($p<0.01$). There were no significant differences observed in the mandible. The authors concluded that smokers with dental implant have a greater risk of developing peri-implantitis.
Kan JYK, Rungcharassaeng K, Lozada JL, Goodacre CJ. 1999[21]	2-	Implant survival in grafted maxillary sinuses. Effect of smoking.	228	Cumulative success rates were significantly different between smokers (65.3%) and non-smokers (82.7%) ($p= 0.027$). There was no correlation though between implant failure and amount of cigarette consumption. The authors concluded that smoking appears to be detrimental to the success of osseointegrated implants in grafted maxillary sinus regardless of cigarette consumption.
Fartash B, Tangerud T, Silness J, Arvidson K 1996[22]	3	Single crystal sapphire implants (Bioceram) and overdentures in the mandible; factors influencing implant survival.	324	Heavy smoking was considered a risk factor. No statistics.
Olson JW, Shernoff AF, Tarlow JL,	3	Dental implant survival in Type 2 diabetic males. Associated	178	Smoking was not significantly related to failure.

Table 2. Effect of smoking on failure of dental implants				
Reference	**Design Score**	**Intervention**	**Total number of implants**	**Key Results**
Colwell JA, Scheetz JP, Bingham SF 2000[23]		risk factors. A variety of implants were used. A conventional maxillary denture and a mandibular implant supported Hader bar clip-retained overdenture was fitted in each patient.		
Bragger U, Aeschlimann S, Burgin W, Hammerle CH, Lang NP. 2001[24]	3	Fixed partial dentures on teeth and implants (ITI system). Biological and technical complications.	105	Biological complications were not significantly associated with smoking.
Eckert SE, Meraw SJ, Weaver AL, Lohse CM. 2001[25]	3	Branemark, Wide-Platform Mk2 implants. Failure rate in partially edentulous arches.	77	Tobacco use had no statistically significant effect on implant survival.
Keller EE, Tolman DE, Eckert SE 1999[26]	3	Dental implant after maxillary antral-nasal autogenous bone graft reconstruction of compromised maxilla. Risk factors influencing survival.	248	Survival rate was 87%. Current use of nicotine was considered to be a risk factor. No statistics were presented.
Feloutzis A, Lang NP, Tonetti MS, et al. 2003[27]	3	Dental implantation (ITI system); effects of smoking and IL-1 gene status in patients with chronic periodontitis.	182	Absolute bone loss was significantly greater in current heavy smokers compared to non smokers ($p<0.02$) and between current heavy smokers and former smokers ($P<0.004$).
Nosaka Y, Tachi Y, Shimpuku H, Kawamura T, Ohura K 2002[28]	3	Dental implantation (Astra Tech AB, Molndal Sweden). Calcitionin receptor gene polymorphism - effect on marginal bone loss after implantation but before adding of the prosthesis.	237	There was no significant difference in the distribution of smoking status between patients with and without bone loss.
Heinikainen M, Vehkalahti M, Murtomaa H. 2002[29]	4	Dental implants, opinion survey of risk factors		Less than 50% of the dentists were prepared to recommend implants where the patient was a heavy smoker.
Anonymous, Faculty of Dentistry, The Royal College of Surgeons. England, 1997[30]	4	Dental implants. Patient selection factors. Consensus Guideline		Tobacco smokers should be counselled to quit or reduce smoking or be refused treatment especially if other risk factors are present.

1.2. Diabetes

Results

Two cohort or case control studies[18, 32] reviewed the effect of diabetes on implant failure (Table 3). The largest[32] included 255 Type 2 diabetic patients followed for 3 years and found that implant failure was increased but the difference was of marginal significance;

Total survival was 93.2% in the non-diabetics and 92.2% in the diabetics. The other case-control study was much smaller[18] and found that the effect of diabetes (Diabetic Type unspecified) was not of statistical significance.

Of the two case series studies, one reported data on Type 2 diabetics[23] and concluded that diabetes was not a contraindication for implant survival, though survival was related to the duration of diabetes. The other study was on both Type 1 and 2[33]. They reported failure rates in diabetics to be increased compared to data commonly reported for non-diabetics but success rates were still considered reasonable.

There is some evidence that the use of preoperative antibiotics and chlorhexidine mouth rinses following implant placement may improve implant survival[32] in diabetics.

Dentists surveyed for their opinion on placing implants in diabetics have in general been cautious[3, 29] (Table 3). A consensus guideline[30] has recommended that dental implants are a suitable intervention in subjects with well controlled diabetes.

Discussion

Dental surgeons have sometimes been hesitant to prescribe dental implants in diabetics because of risk of delayed wound healing, increased risk of infection, increased risk of microvascular pathology and other factors[23]. In the DICRG study Type I diabetics were excluded from entry. The papers reviewed here suggest there is little evidence that implant failure is increased to a clinically significant degree in well-controlled Type 2 diabetics. In the largest trial[32] absolute increase in risk was only one percent at three years. The consensus guideline and surveys of dental opinion appear to reflect well, the low level of increased risk that most well-controlled Type 2 diabetics are likely to face. No papers were reviewed that investigated exclusively the effect of Type 1 diabetes on implant outcome and therefore the impact of this condition is not known.

Suggested Recommendation	Dental implants are a suitable intervention for Type 2 Diabetics who are well controlled and do not have other relevant risk factors.

Referees' Comments

We agree that the literature supports the suggested recommendation that dental implants are a suitable intervention for Type 2 Diabetics who are well controlled and do not have other relevant risk factors. In developing patient selection guidelines, self-reporting of "well controlled "status is unlikely to be a reliable indicator of the patient's diabetic status and supporting documentation from the treating physician may be indicated.

Table 3. Effect of diabetes on the survival of dental implants.

Reference	*Design Score*	*Intervention*	*Total number of implants*	*Key Results*
Butterworth CJ, Baxter AM, Shaw MJ, Bradnock G. 2001[3]	4	Dental implantation (70% Branemark) Survey of risk factors		About 35% of dentists surveyed considered that IDDM was an important patient selection factor to be considered.
Elsubeihi ES, rb GA. 2002[18]	2-	Dental implants, effect of diabetes	170	RR for failure in diabetics compared to failure in nondiabetics was 1.08 (95% CI 0.33-3.52), and was not significant.

Table 3. Effect of diabetes on the survival of dental implants.				
Reference	***Design Score***	***Intervention***	***Total number of implants***	***Key Results***
		(Type not described) on implant failure.		
Olson JW, Shernoff AF, Tarlow JL, Colwell JA, Scheetz JP, Bingham SF 2000[23]	3	Dental implant survival in Type 2 diabetic males. Associated risk factors. A variety of implants were used. A conventional maxillary denture and a mandibular implant supported Hader bar clip-retained overdenture was fitted in each patient.	178	Implant survival was 88% from prosthesis placement through follow up of 5 years. Duration of diabetes ($p<0.025$) was related to implant failure. HbA1c, fasting plasma glucose and baseline diabetic therapy were not significantly related to failure. The authors' concluded that type 2 diabetes was not a contraindication for implantation.
Heinikainen M, Vehkalahti M, Murtomaa H. 2002[29]	4	Dental implants, opinion survey of risk factors		Less than 50% of the dentists were prepared to recommend implants where the patient had poorly controlled diabetes mellitus.
Anonymous, Faculty of Dentistry, The Royal College of Surgeons. England, 1997.[30]	4	Dental implants. Patient selection factors. Consensus guideline		A general recommendation was that subjects with diabetes mellitus should be well controlled.
Morris HF, Ochi S, Winkler S 2000[32]	2+	Dental implants, effect of diabetes (Type 2) on failure rates	2887 (255 diabetics)	Implant failure was significantly worse in the diabetics ($p=0.046$). The use of hydroxyapatite coated implants improved outcomes in the diabetics by 13.2%. The use of chlorhexidine rinses following implant placement and preoperative antibiotics also improved outcomes for the diabetics (no statistics reported). Bone density did not appear to be a major influence on implant survival in diabetics. The RR of failure in diabetics compared to non-diabetics was 1.15 (95% CI 0.74 - 1.79). No statistics were reported to support some of the conclusions reached.
Fiorellini JP, Chen PK, Nevins M, Nevins ML. 2000[33]	3	Factors influencing implant (Branemark, ITI) survival in diabetic patients (Type 1 and 2).	215	The overall success rate was 85.6% at a mean follow up of 4.1 years. The authors' concluded that though implant survival was lower in diabetics than in the general population there was still a reasonable success rate.

1.3. Parafunction including Bruxism

Results

Five studies reported on the effect of bruxism or parafunction on implant failure (Table 4).

- One RCT in a supplementary analysis of factors, found that bruxism was significantly related to implant failure[34]
- Ekfeldt et al (2001)[17] concluded that bruxism was a likely contributor to multiple implant failure in the maxilla but presented no statistics
- One case series study[24] found the risk of failure to be 3.5 times that of non bruxers and another [35] reported a higher failure rate in bruxers but this was not significant
- One study[25] found bruxism to have no effect
- A survey of dentist opinion[3] reported that 55% thought parafunctional habits to be important factors influencing patient selection and the Faculty of Dentistry of the Royal College of Surgeons[30] state in their consensus guideline that caution should be exercised in accepting patients with suspected bruxism and parafunctional activities.

Discussion

Parafunction has been defined as disordered, non physiological function and includes clenching and grinding (bruxism)[31]. It can lead to very high forces that could contribute to implant failure. The evidence that parafunction contributes to implant failure is only modest, depends on supplementary analyses of studies investigating other factors and is not always considered an important factor even then. The opinion of dentists though and the one consensus guideline reviewed, favour caution in selecting such patients for dental implants.

Suggested Recommendation	Caution should be exercised in accepting patients with suspected bruxism and other parafunctional activities.

Referees' Comments

We agree that the literature supports the suggested recommendation. The literature indicates that most fixed prosthodontic treatment results from dental wear from clenching and grinding and/or to redirect the heavy occlusal loads through the teeth and the restorations best suited to receive them [9]. This may be done as a reorganized occlusion to establish a new occlusal scheme. An optimally constructed occlusion may be better able to deal with the forces generated by parafunction but usually involves treatment of most or all of the teeth in one or both dental arches. Dental management of parafunction is more difficult when only localized regions of the mouth are being treated where there is less opportunity to control the patient's occlusal scheme. If ACC were providing benefits for implant replacement of an isolated tooth, it would seem unrealistic for ACC to provide benefits for treatment of most or all of the other teeth in the arch to allow the restoration to be placed in an area free of contributing parafunctional forces.

Table 4. Effect of bruxism on implant failure.				
Reference	***Design Score***	***Intervention***	***Number of implants***	***Key Results***
Butterworth CJ, Baxter AM, Shaw MJ, Bradnock G. 2001[3]	4	Dental implantation (70% Branemark) Survey of risk factors		55% of dentists surveyed thought parafunctional habits to be important factors influencing patient selection.
Ekfeldt A, Christiansson U, Eriksson T, et al 2001[17]	2-	A fixed prosthesis or an overdenture supported by at least 4 implants (Branemark System) in the maxilla. Factors associated with multiple implant failure.	301	Bruxism was considered a likely contributor to multiple implant failure. No statistics were presented.
Bragger U, Aeschlimann S, Burgin W, Hammerle CH, Lang NP. 2001[24]	3	Fixed partial dentures on teeth and implants (ITI system). Biological and technical complications.	105	Technical complications were significantly associated with bruxism ($p<.01$). The RR for a technical complication in bruxers compared to non bruxers was 3.46 (95% CI 1.71 - 7.02).
Eckert SE, Meraw SJ, Weaver AL, Lohse CM. 2001[25]	3	Branemark, Wide-Platform Mk2 implants. Failure rate in partially edentulous arches..	77	Bruxism had no statistically significant effect on implant survival.
Anonymous, Faculty of Dentistry, The Royal College of Surgeons[30]. England, 1997[30].	4	Dental implants. Patient selection factors. Consensus guideline.		Caution should be exercised in accepting patients with suspected bruxism and other parafunctional activities.
Wannfors K, Johansson B, Hallman M, Standkvist T. 2000[34]	1-	Sinus grafting by a one or two stage technique. Factors related to implant failure.	150	Bruxism ($p<0.05$) was related to implant failure.
Glauser R, Ree A, Lundgren A, Gottlow J, Hammerle CH, Scharer P, 2001[35].	3	Immediate loading of implants (Branemark) in a one stage procedure after tooth extracted. Prostheses placed immediately or within 11 days. Guided bone regeneration when required. Implant survival and associated risk factors	127	Implants in bruxers (41%) were lost more frequently than in non-bruxers (12%) but this was not of statistical significance when analysed at patient level.

1.4. Bone Grafting

Results

Seven papers were reviewed that referred to implant survival or factors effecting survival in situations where bone grafting occurred. An RCT[34] comparing failure rates after bone grafting by either a one or two stage method reported that failure in grafted bone was, depending on method, 4 to 9 times more common than in non grafted bone. Esposito et al[12], summarising data from a 16 papers of unstated design quality, also reported a rate at least twice that of non grafted implants. One cohort study reported success rates in grafted bone of 89.9%[21] and in two case series studies the rates were 87%[26] and 98%[36] (after management of immediate and short term complications). One smaller case series study[25] reported grafting had no significant effect on the success rate. The Faculty of Dentistry[30] of the Royal College of Surgeons concluded that implants placed in grafted bone have significantly higher failure rates.

Discussion

To enhance bone volume in the sinus cavities of the posterior maxilla, bone-grafting procedures have been introduced. Methods have included placing blocks of autogenous bone into which implants are fixed and placing of harvested, particulated bone onto the floors of the maxillary sinuses followed at a latter date by implant placement[34]. While the data reviewed here are not completely consistent, on balance it would appear that implant failure is often significantly increased to a degree that is likely to be of clinical relevance. In the worst situation, failure was increased by nearly nine times[34] that of implants at non grafted sites. An average value is likely to be the 14% failure rate reported by Esposito et al (1998)[12].

Comment	Dental implants located after maxillary sinus augmentation have an increased failure rate that is likely to be of clinical significance.

Referees' Comment

The papers reviewed relate to a specific bone grafting procedure, namely maxillary sinus augmentation. Bone grafting is not limited to this region and there is no authoritative data on implant success in other areas that have undergone other grafting procedures. The scope and magnitude of bone grafting vary widely from Level 1 bone grafts defined under ACC regulations as" bone grafting involving minimal degrees of difficulty where bone is collected from twist drills to enhance minor defects and alveolar discrepancies. It may be combined with allograft or a synthetic bone replacement material and may be done in conjunction with a membrane" to Level 3, 4 and 5 bone grafts that involve large bone volumes harvested from intra oral or extra oral iliac crest sites. The Level 3 4 and 5 grafts are done in a hospital sitting and are considered significant surgical events. It would be incorrect to make a general comment concerning bone grafting and its impact on implant success without analyzing the type of bone graft. The magnitude of bone graft, the type of implant material used and certainly the location of the implant will contribute to the success of placing implants in grafted bone. The comment presented in the draft is influenced not only by the grafting event, but the documented decrease in implant success rates in fully edentulous maxilla compared to mandibles. A study by Pinholt in 2003 [[10]] found that machined titanium fixtures had a lower survival rate in autogenous grafted bone (81%) than large grit acid etched surface treated ITI implants (98%).

Table 5. Effect of bone grafting on implant survival and risk factors associated with survival.

Reference	*Design Score*	*Intervention*	*Total number of implants*	*Key Results*
Esposito M, Hirsch JM, Lekholm U, Thomsen P. 1998.[12]	2-	Dental implants (Branemark only). Effect of biological factors on implant failure. 16 papers investigated the effect of bone grafting.	1833 implants in bone grafted situations	Biologically related implant failure in a total of 2,812 implants was 7.7% over a 5-year period (bone graft cases excluded). The failure rate of implants in bone graft situations was much higher (14.9%).
Kan JYK, Rungcharassaeng K, Lozada JL, Goodacre CJ. 1999[21]	2-	Implant survival in grafted maxillary sinuses. Effect of smoking.	228	At a mean follow up of 41.6 months 89.9% of the implants were still functioning.
Eckert SE, Meraw	3	Branemark, Wide-Platform	77	Sinus grafting had no statistically significant effect on

Table 5. Effect of bone grafting on implant survival and risk factors associated with survival.				
Reference	***Design Score***	***Intervention***	***Total number of implants***	***Key Results***
SJ, Weaver AL, Lohse CM. 2001[25]		Mk2 implants. Failure rate in partially edentulous arches.		implant survival.
Keller EE, Tolman DE, Eckert SE 1999[26]	3	Dental implant after maxillary antral-nasal autogenous bone graft reconstruction of compromised maxilla. Risk factors influencing survival.	248	Survival rate was 87% .
Anonymous, Faculty of Dentistry, The Royal College of Surgeons. England, 1997[30].	4	Dental implants. Patient selection factors. Consensus guideline.		Implants placed in grafted bone have significantly higher failure rates.
Wannfors K, Johansson B, Hallman M, Standkvist T. 2000[34]	1-	Sinus grafting by a one or two stage technique. Factors related to implant failure.	150	Of the implants in grafted regions done by a one-stage system, 79% survived at one year. The failure rate was 8.9 times that of implants in non-grafted regions (95% CI, 2.9 – 28). For the two-stage system the failure rate was 89% . The failure rate was 4.1 times that of non-grafted implants (95% CI 1.2 – 14).
Chanavaz M. 1996[36]	3	Sinus grafting prior to implantation. Factors relating to patient selection. A variety of methods and materials were used over a period of 15 years.	(402 patients)	Long-term success was obtained in 98.5% of cases after management of immediate and short term complications.

1.5. Bone Quality and Volume

Results

Only two papers were reviewed that had as a main goal the assessment of bone quality on implant success[32, 37] (Table 6). Implants placed in thin cortical bone had a slightly increased risk of failure over that placed in thicker bone: the difference was of marginal significance[37]. In the DICRG study[32] bone quality was a significant correlate of implant success but the relationship was not simple; Those with bone quality 4 (bone of the lowest quality) had a lower failure rate than those with bone quality 3. A case control study[17] concluded that bone quality contributed to multiple implant failure but presented no statistics and Orestein et al (1998)[38] found that bone quality significantly effected the incidence of implant movement at placement. Fartash et al (1996)[22] concluded from their case series study that the main risk factor for implant loss was an association between bone quality and anatomy, but provided no statistics.
The consensus guideline from the Faculty of Dentistry, Royal College of Surgeons[30] concluded that adequate bone quality and volume were prerequisites for treatment.

Discussion

The evidence for the importance of bone quality and volume in determining implant success is surprisingly slight. In part this may result from the exclusion from treatment of patients who have obviously inadequate bone structure. Occasionally, the literature refers to the higher failure rate reported for the maxilla compared to the mandible as evidence for the importance of bone quality and volume eg[31]. A classification scheme for bone quality and quantity has been proposed[39] but not apparently not validated[40].

Comment	It would seem that a consensus opinion is required to set parameters for bone quality and quantity.

Referees' Comments

While there are some published guidelines on bone quality and quantity such as those of Lekholm and Zarb (1985) [[11]], we agree with the comment that it would seem that a consensus opinion is required to set parameters for bone quality and quantity. Low bone density at the implant site has been associated with a higher than expected implant failure rate in both retrospective studies by Jaffin and Berman and in prospective investigations by Hutton et al. Unfortunately assessment of bone density and volume are often made at the time of surgery and would not be productive selection criteria based on our current technology.

Table 6. Effect of bone quality on implant failure.

Reference	*Design Score*	*Intervention*	*Total number of implants*	*Key Results*
Ekfeldt A, Christiansson U, Eriksson T, et al 2001[17]	2-	A fixed prosthesis or an overdenture supported by at least 4 implants (Branemark System) in the maxilla. Factors associated with multiple implant failure.	301	A factor thought likely to contribute to multiple implant failure was lack of bone support. No statistics were presented.
Fartash B, Tangerud T, Silness J, Arvidson K 1996[22]	3	Single crystal sapphire implants (Bioceram) and overdentures in the mandible; factors influencing implant survival.	324	The main risk factor for implant loss was an association between bone quality and anatomy. No statistics were presented.
Anonymous, Faculty of Dentistry, The Royal College of Surgeons. England, 1997[30].	4	Dental implants. Patient selection factors. Consensus guideline.		There should be adequate bone quality and volume.
Morris HF, Ochi S, Winkler S 2000[32]	2+	Dental implants, effect of diabetes on failure rates	2887	In all patients bone quality (p=0.0104) was a highly significant correlate of implant success. In non diabetics the failure rates for patients with bone quality 1, 2, 3, and 4 were respectively 5.0%, 6.2%, 8.0% and 6.8%.

Table 6. Effect of bone quality on implant failure.				
Reference	***Design Score***	***Intervention***	***Total number of implants***	***Key Results***
Becker W, Hujoel PP, Becker BE, Willingham H, 2000[37]	2-	Effect of osteoporosis and bone quality on implant (Branemark) failure.	364	Simple visual assessment of local bone quality was related to implant failure; Implants placed in thin cortical bone had a slightly increased risk of loss (130%) compared to implants in a thick cortical layer or compact bone (RR 2.3, 95% CI, 1.0- 5.4).
Orenstein IH, Tarnow DP, Morris HF, Ochi S 1998[38]	2-	Mobility of the implant at time of placement. Factors related to this	2641	A patient selection variable associated with mobility at placement was bone quality-4 - compared to those with bone quality in grades Q1 to Q3 (p=0.009).

1.6. Osteoporosis, HRT and menopausal status

Results

Five papers were reviewed that addressed the impact of osteoporosis, use of hormone replacement therapy or menopausal status on implant survival (Table 7).

- A case-control study[37] found that osteoporosis as assessed by dexa scanning of the ulna and radius was not related to implant loss
- A second case-control study[41] reported that in post menopausal females bone loss after implantation was related to bone density as assessed by dexa scanning but this was not interpreted as a contraindication for implant placement
- A case series study[36] found that loss of implants after bone grafting occurred mainly in a group of post menopausal women who were in poor health
- A study of case series data[28] found no relation between menopausal status and implant loss in Japanese women
- An analysis of case series data could find no clinical effect of HRT on implant survival[42] but no statistics were presented.

Discussion

Obtaining a good bone-implant bond is a concept inherent to osseointegration and factors influencing bone metabolism may potentially effect implant survival. It would appear though that while there is some evidence that menopausal status/osteoporosis does effect bone loss around the implant[41], osteoporosis is not necessarily associated with implant loss[37]. Osteoporosis and postmenopausal status appear not to be major risk factors for implant survival. The available evidence suggests the use of HRT is also not of benefit.

Suggested Recommendation	Postmenopausal status and mild osteoporosis are probably not clinically relevant risk factors for implant loss in most patients.

Referees' Comments

The presence of a postmenopausal status, osteoporosis or HRT in and of themselves may not pose a significant risk factor for implant success, but must be considered in any algorithm to assess the synergistic effects and increased risk when multiple risk factors are present.

Table 7. Effect of osteoporosis, use of hormone replacement therapy and menopausal status on implant survival				
Reference	***Design Score***	***Intervention***	***Total number of implants***	***Key Results***
Nosaka Y, Tachi Y, Shimpuku H, Kawamura T, Ohura K 2002[28]	3	Dental implantation (Astra Tech AB, Molndal Sweden). Calcitionin receptor gene polymorphism - effect on marginal bone loss after implantation but before adding of the prosthesis.	237	There was no significant difference in the distribution of postmenopausal status between patients with and without bone loss.
Chanavanz M. 1996[36]	3	Sinus grafting prior to implantation. Factors relating to patient selection. A variety of methods and materials were used over a period of 15 years.	(402 patients)	Long-term success was obtained in 98.5% of cases after management of immediate and short term complications. The 6 failures were all found in the 120 post menopausal women (5%). Five of these 6 women were in poor health.
Becker W, Hujoel PP, Becker BE, Willingham H, 2000[37]	2-	Effect of osteoporosis and bone quality on implant (Branemark) failure.	364	Osteoporosis as assessed by dexa scanning of the ulna and radius was not significantly related to implant loss. Simple visual assessment of local bone quality was related to implant failure.
von Wowern N, Gotfredsen K. 2001[41]	2-	Bone mineral content (Dexa scanning) of the mandible at prosthesis placement and, 2 and 5 years later. Prosthesis was supported on Astra implants held by either a bar or ball system. The effect of osteoporosis pretreatment on bone mineral loss in the mandible was also investigated.	44	An analysis of bone loss in postmenopausal females in relation to the bone mineral content at baseline suggested that those with the lowest bone mineral content pre-treatment had the greatest bone loss post implantation ($p<0.01$). Osteoporosis prior to implantation may be a risk factor for bone loss around the implant but this is an indicator for maximising oral hygiene and other possible interventions, rather than a contraindication of implantation.
Minsk L, Polson AM 1998[42]	3	Implant survival, effect of hormone replacement therapy (HRT) on outcome	450	HRT had no clinically significant effect on implant survival. No statistics presented.

1.7. Hypothyroidism

Results

One paper was reviewed[43] that investigated the effect of hypothyroidism on implant survival (Table 8). This case-control study found that in hypothyroid patients who were on replacement medication, implant survival was not significantly lower although more bone loss occurred around the implant.

Discussion

Thyroid disorders and thyroid hormone medications influence bone metabolism and regulate wound healing[43]. The indication is that well controlled hypothyroidism is not in itself a contraindication for implantation although the evidence to support this view is limited to one well-conducted study.

Suggested Recommendation	Implants are not usually contraindicated in hypothyroid patients who are well-controlled on replacement therapy.

Referees' Comments
Self-reporting should be avoided and supporting documentation obtained from the physician. Hypothyroidism in association with other risk factors requires separate consideration.

Table 8. Effect of hypothyroidism on implant survival.

Reference	*Design Score*	*Intervention*	*Total number of implants*	*Key Results*
Attard NJ, Zarb GA 2002[43]	2+	Implantation (Branemark) in hypothyroid patients	82	There was no statistical difference in failure rate between the hypothyroid group and the controls (p=0.781). The hypothyroid group had more soft tissue complications (p=0.018) following stage one surgery but these were minor in nature. More bone loss around the implants occurred after 1 year in the hypothyroid group (p=0.017).

1.8. Cardiovascular Disease

Results

Only one paper[44] (Table 9) was reviewed that examined the effect of cardiovascular disease on implant failure rates. The failure rate was not increased in patients with cardiovascular disease. A survey of dental opinion[29] concluded that myocardial infarction was not generally considered to be an important contraindication for implantation.

Discussion

Cardiovascular diseases that effect blood supply may be detrimental to implant survival. The evidence reviewed here has not included large numbers of patients but it does not appear to be an important risk factor.

Suggested Recommendation	Implants are not usually contraindicated in patients with cardiovascular disease where it is well controlled.

Referees' Comments
We agree that the literature supports the suggested recommendation that implants are not usually contraindicated in patients with cardiovascular disease where it is well controlled. There is no suggestion that cardiovascular disease poses any risk for implant success. The precautions take for cardiovascular disease patients would be the same for any surgical procedure and would be based on the provider's consultation with the patients treating physician. Cardiovascular disease would not be relevant for the risk evaluation algorithm.

Table 9. Effect of cardiovascular disease on implant survival.

Reference	*Design Score*	*Intervention*	*Number of patients*	*Key Results*
Heinikainen M, Vehkalahti M, Murtomaa H. 2002[29]	4	Dental implants, opinion survey of risk factors		Past myocardial infarction was not generally considered an important reason to decline implantation.

Table 9. Effect of cardiovascular disease on implant survival.				
Reference	***Design Score***	***Intervention***	***Number of patients***	***Key Results***
Khadivi V, Anderson J, Zarb GA. 1999[44]	2-	Effect of cardiovascular disease (hpertension, myocardial infaction, angina, mitral valve prolapse) on implant (Branemark) survival.	246 patients in total, 39 with relevant CVD.	The failure rates were 12.8%, 12.2% and 13.8 % respectively for the cardiovascular, healthy and 'other systemic diseases' groups. These differences were not significant.

1.9. Irradiation of the jaw

Results

Two papers were reviewed that addressed the effects of irradiation of the jaw on implant survival (Table 10). Esposito et al (1998)[45] conducted a simple meta-analysis of data based on 7 studies published in 1998 or earlier. They found that the failure rate was 4.9% in the mandible and 29.2% in the maxillae of patients who had previously had irradiation, typically for treatment of various cancers. This compares with failure rates around 3% (mandible) to 8% (maxilla) for non irradiated patients[12, 45]. The increased rate of failure in the mandible due to irradiation appears to be relatively small. One additional paper was found not covered in the above review[46] where the overall failure rate in irradiated patients was 86% compared to 94% in non irradiated patients.
Esposito's analysis also reviewed the effect of total radiation dose on implant success rate. It would appear that patients receiving total doses greater than 54 Gy are at a greatly increased risk of implant failure. Again the failure rate in the mandible is only marginally increased whereas about one-fifth of implants in the maxilla failed. A survey of dental opinion[3] found that 70% of dentists considered irradiation to be a contraindication.

Discussion

Though the number of patients reported on is not large for all categories there is some evidence indicating higher rates of implant failure in patients previously exposed to irradiation for cancer. The tentative indications are that the risk of failure is much greater for implants in the maxilla. Failure rates in the maxillae appear to be greatly increased when the total irradiation dose has exceeded 54 Gy. While the data reviewed suggest that failure rates in the mandible appear to be only marginally increased, regardless of total irradiation dose, the referees of the report have another perspective (see below).

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

Referees' Comments
Irradiation of head and neck tumors predispose to changes in bone, skin and mucosa. Long term function of osseointegrated implants is dependent on the presence of viable bone that is capable of remodeling and turnover as the implant is subjected to stresses associated with supporting, retaining and stabilizing prosthetic restorations. Bone is 1.8 times as dense as soft tissue, and

therefore absorbs a larger proportion of radiation than a comparable volume of soft tissue and the mandible absorbs more radiation than the maxilla because of its increased density. This, plus the mandible's reduced vacularity compared to the maxilla, accounts for the higher incidence of mandibular osteoradionecrosis (osteoradionecrosis is defined as exposure of bone within the radiation treatment volume of 3 months or longer in duration and is a complication of radiotherapy that may progress to intractable pain and pathologic fracture of the mandible). The risk is related to mode of therapy (external source v implantation), radiation field, mandible v maxilla (almost all osteoradionecroses occur in the mandible [12-17] and dose to bone (risk of osteoradionecrosis is significantly lower when the dosage is below 55 Gy). Because of the risk of osteoradionecrosis in the irradiated mandible, relatively few cases have been treated where implants are placed in a radiated field where the dose to bone is greater than 55 Gy. Implants placed in the mandible, outside the field of radiation or in free bone grafts, have a success rate of up to 90% [14].

When implants are considered for the irradiated patient, several issues require careful consideration such as the risk of osteoradionecrosis, the potential benefit provided by implants, the potential morbidity associated implant failure or complications (such as osteoradionecrosis), and the potential usefulness of hyperbaric oxygen [18, 19].

Table 10. Effect of irradiation of the jaw on implant survival.

Reference	*Design Score*	*Intervention*	*Total number of implants*	*Key Results*
Butterworth CJ, Baxter AM, Shaw MJ, Bradnock G. 2001[3]	4	Dental implantation (70% Branemark) Survey of risk factors		70% of respondents thought that previous irradiation (70%) was an important medical factor contraindicating implantation.
Esposito M, Hirsch JM, Lekholm U, Thomsen P. 1998[45]	2-	Dental implants (Branemark only). Effect of biological factors on implant failure.	485	A simple meta-analysis of data was provided for the effect of irradiation therapy. Based on seven studies the failure rate in the maxilla was 29 of 99 implants (29.2%), and in the mandible 19 of 386 implants (4.9%) (Some of these patients had also received hyperbaric oxygen therapy). Based on 6 studies the effect of total irradiation dose was calculable. Doses less than 55Gy, resulted in a total failure rate 2.6% (1.6% mandible, 6.6% maxilla), and for greater than or equal to 55 Gy the rate was 10.1% (6.9% mandible, 22.9% maxilla).
Weischer T, Mohr C. 1999[46]	2-	Survival of implants in patients previously bone irradiated for oral cancer. Comparison with soft tissue irradiated patients. Comparison of complications with prostheses supported on implants, and implants and tissue.	175	The adjusted cumulative success rate was 86% in the irradiated group and 94% in the non-irradiated after 5 years. The authors' concluded that the irradiated patients should only receive exclusively implant-supported prostheses to avoid problems with ulceration when the prosthesis rests partly on implant and partly on tissue.

1.10. Gene polymorphism (Interleukin and Calcitonin)

Results

Three papers were reviewed that investigated the effect of interleukin polymorphism on the rate of implant failure (Table 11). Two case-control papers[16 47] found no difference in implant failure rate between various genotypes. One case series paper[27] found that in those that were IL-positive, bone loss was significantly greater in heavy smokers compared to non-smokers.
One paper[28] was reviewed that investigated the effect of polymorphism in the calcitonin receptor gene. They found that bone loss was significantly greater with one particular gene type but the effect was confined to the mandible.

Discussion

Interleukin-1 (IL-1) has been associated with a broad spectrum of responses that result in the degradation of bone and subjects with advanced peri-implant infections have increased levels of IL-1 at these sites. Subjects with a particular IL-1 genotype produce high levels of IL-1[27]. The evidence for the idea that implant failure is related to a particular IL genotype has not been confirmed in the papers reviewed here, although in one paper there was an indication that in patients with chronic periodontitis there was an interaction between genotype and smoking.

Polymorphism in the calcitonin receptor gene may be related to bone loss around the implant.

Comment	There seems insufficient evidence at this stage to make any recommendations as to the relevance of gene studies to patient selection for dental implants.

Referees' Comments
Further research into the role of genetic polymorphisms is needed. At this time in New Zealand there is no established protocol to evaluate the presence of suspected genetic risk factors. No recommendations can be made at this time as to the relevance of genetic factors as a patient selection criterion.

Table 11. Effect of interleukin and calcitionin polymorphisms on the survival rate of dental implants.

Reference	*Design Score*	*Intervention*	*Total number of implants*	*Key Results*
Wilson TG, Jr., Nunn M 1999[16]	2-	Relation of interleukin -1 genotype to implant (Branemark and Straumann) failure. The kit used to identify genotype status is referenced but not described.. (Patients with failed or successful implants on clinic records)	101	Statistical testing showed no difference in the distribution of genotypes between implant failures and successes.
Feloutzis A, Lang NP, Tonetti	3	Dental implantation (ITI system); effects of smoking and IL-1 gene status in patients with chronic periodontitis.	182	Upon stratification by smoking status it was shown that in those who were IL –positive, bone loss was significantly greater in heavy smokers compared to non smokers ($p<0.01$). In non smokers IL-1 genotype status could not

Table 11. Effect of interleukin and calcitionin polymorphisms on the survival rate of dental implants.				
Reference	***Design Score***	***Intervention***	***Total number of implants***	***Key Results***
MS, et al. 2003[27]				discriminate between those with and without bone loss.
Nosaka Y, Tachi Y, Shimpuku H, Kawamura T, Ohura K 2002[28]	3	Dental implantation (Astra Tech AB, Molndal Sweden). Calcitonin receptor gene polymorphism - effect on marginal bone loss after implantation but before adding of the prosthesis.	237	Those with the TC gene type were 20 times more likely to suffer buccal marginal bone loss in the mandible than those with the CC genotype during the first phase of treatment - placement of implantation but before connection of the abutments (p=.004, RR 20.0 (95% CI 2.62-152.64). The effect was not observed in the maxilla.
Rogers MA, Figliomeni L, Baluchova K, et al, 2002[47]	2-	Frequency of polymorphism in the interleukin (IL)-1 loci, [IL-1A(-889), IL-1B(+3953) alleles, and a composite genotype IL-1A (-889)2 plus IL-1B(+3953)2]. Relation to implant failure. (Patients with failed and successful dental implants and healthy individuals.)	(179 patients including controls)	IL-1A (-889), IL-1B(+3953) or the composite genotype showed no association with failure of dental implants.

1.11. Infection, periodontitis, poor oral hygiene and uncontrolled caries

Results

Two papers[34, 48] were found that referred to the impact of infection on implant failure (Table 12). In only one of the studies[48] was the effect of statistical significance. One case series study[49] concluded that past periodontitis was a reason for implant failure. Surveys of dental opinion[3, 29] report that significant numbers of dental surgeons did not recommend implants where oral hygiene was deficient, untreated caries or periodontitis was present or the patient had several deep periodontal pockets. The consensus guideline from the Faculty of Dentistry of the Royal College of Surgeons[30] recommends that the patient should have healthy mucous membranes, dentate subjects should have healthy periodontal tissues and sound teeth, and poor oral hygiene, untreated periodontal disease and uncontrolled caries are contra-indications.

Discussion

The presence of infection[10, 27, 50] and poor oral hygeine[10, 51] is a common cause for exclusion of patients from dental implant studies, and dental opinion favours the exclusion of patients who have uncontrolled caries, poor oral hygiene, periodontitis or unresolved infection. The evidence base for excluding patients with infection, poor oral hygiene, uncontrolled caries and periodontitis, as reviewed here relies almost entirely on consensus opinion.

Comment	It is a consensus opinion that patients with infection, poor oral hygiene, uncontrolled caries and periodontitis should be excluded as candidates for dental implants.

Referees' Comments

Failure to manage periodontal disease, caries and infection and to maintain good oral hygiene prior to implant placement can result in failure of the implant treatment and/or the loss of other teeth [38, 39] (Mombelli and Lang 1992 Cune and dePutter 1996 and Gouvoussis 1997). The loss of other teeth potentially compromises implant treatment already provided because additional tooth loss can result in loss of posterior dental support causing occlusal overloading of the remaining teeth or it can make restoration of the edentulous space more difficult when teeth adjacent to an implant restoration are lost. It seems imperative that oral hygiene status, uncontrolled caries and untreated periodontitis should be incorporated into the patient selection criteria established by ACC or any other service provider. This may be a difficult criterion to assess and enforce, with prejudicial patient self-reporting and bias by the provider to facilitate the approval of implant treatment for their patient.

Table 12. The effect of infection and periodontitis on implant failure.				
Reference	***Design Score***	***Intervention***	***Total number of implants***	***Key Results***
Butterworth CJ, Baxter AM, Shaw MJ, Bradnock G. 2001[3]	4	Dental implantation (70% Branemark) Survey of risk factors		Untreated periodontitis (95% of dentists surveyed), poor oral hygiene (80%) and uncontrolled caries (75%) were the most important oral contra-indications.
Heinikainen M, Vehkalahti M, Murtomaa H. 2002[29]	4	Dental implants, opinion survey of risk factors		Less than 50% of the dentists were prepared to recommend implants where oral hygiene was deficient, untreated caries was present or the patient had several deep periodontal pockets
Anonymous, Faculty of Dentistry, The Royal College of Surgeons. England, 1997[30].	4	Dental implants. Patient selection factors. Consensus guideline.		General oral/dental factors were- The patient should have healthy mucous membranes, Dentate subjects should have healthy periodontal tissues and sound teeth, Poor oral hygiene, untreated periodontal disease and uncontrolled caries are contra-indications,
Wannfors K, Johansson B, Hallman M, Standkvist T. 2000[34]	1-	Sinus grafting by a one or two stage technique. Factors related to implant failure.	150	Post operative infections (P<0.07) were related marginally to implant failure. Significance was dependent on statistical test applied.
Wang IC, Reddy MS, Geurs NC, Jeffcoat MK 1996[48]	3	Dental implant (Steri-Oss) survival. Risk factors associated with survival	83	The presence of infection was significantly related to implant failure (p<0.001).
Polizzi G, Grunder U, Goene R, et al. 2000[49].	3	Placement of implant (Branecare) either immediately into the extraction socket or after 3 to 5 weeks of healing. Survival rate and factors related to survival.	264	The 5 year survival rate in a total of 143 consecutive patients was 92.4% for the maxilla and 94.7% for the mandible. The authors' considered that there was a clinical correlation between implant failure and periodontitis as a reason for tooth extraction but this was not statistically significant.

1.12. General Health Status

Results

Four studies were found that reported the effect of health status on implant failure rates (Table 13). In three of these studies[32, 45, 52] it was concluded that the patient's health status

was a cause of implant failure; In two of the studies[32, 52] the conclusion was supported by statistical analysis. One case series study[24] reported that health status had no effect on outcome.

Discussion

There is some evidence from relatively large studies that health status is related to risk of implant failure and it is notable that many of the studies reviewed here, included poor health as an exclusion criterion (eg[27, 28, 41, 42]).

The above findings and practice is in accord with the opinion of the Faculty of Dentistry of the Royal College of Surgeons[30] who suggest that candidates for dental implants should have sufficiently good general health to undergo surgical and prosthodontic treatment.

Suggested Recommendation	Candidates for dental implants should have sufficiently good general health to undergo surgical and prosthodontic treatment[30].

Referees' Comments

It is clear that the candidates for dental implants should have sufficiently good general health to undergo surgical and prosthodontic treatment. Type 1 diabetes, should be considered a significant risk factor in implant success (Shernoff et al 1994 and Oikarinen et al 1995). Alcohol and substance abusers, as well as patients with psychological and mental disorders who are not reliable with regards to compliance, home care and follow up appointments may not be considered suitable candidates for dental implant treatment. (Hogenius et al. 1992).

Table 13. Effect of general health status on implant failure rates

Reference	*Design Score*	*Intervention*	*Total number of implants*	*Key Results*
Bragger U, Aeschlimann S, Burgin W, Hammerle CH, Lang NP. 2001[24]	3	Fixed partial dentures on teeth and implants (ITI system). Biological and technical complications.	105	Biological complications with implants were not significantly associated with impaired general health.
Anonymous, Faculty of Dentistry, The Royal College of Surgeons. England, 1997[30].	4	Dental implants. Patient selection factors. Consensus guideline.		General health should be good enough to undergo surgical and prosthodontic treatment,
Morris HF, Ochi S, Winkler S 2000[32]	2+	Dental implants, effect of diabetes on failure rates	2887	In all patients health status (p=0.0145) was a highly significant correlate of implant success.
Esposito M, Hirsch JM, Lekholm U, Thomsen P. 1998.[45]	2-	Dental implants (Branemark only). Effect of biological factors on implant failure.		Medical status of patient was related to implant failure – no statistics presented.
Attard NJ, Zarb GA, 2003[52]	3	Implants (Branemark) in posterior positions. Implant outcome and host determinants.	432	Implant survival was correlated with a history of chronic medical conditions (p=0.01).

1.13. Survival of teeth adjacent to an implant or an edentulous space

Results and Discussion

The effect of placing an implant-supported prosthesis in a bounded edentulous space (BES) does not appear to have been widely investigated. One study was reviewed that investigated the effect of placing either a fixed partial denture or a removable denture into a bounded edentulous space and compared the outcome on teeth adjacent to the space with that in patients who received no treatment[53] (Table 14). (It was not clear from the report though how many of the prostheses were supported on implants). The authors concluded from the study that there was little evidence to support the idea that posterior BES should be restored to prevent loss of additional teeth though a fixed partial denture will result in a small improvement in survival of adjacent teeth.

A second study[54] investigated the effect of a single implant on the adjacent teeth and concluded that such teeth subsequently have a very low rate of complication.

Comment	In bounded edentulous spaces there is an indication that teeth adjacent to a single tooth implant have a very low rate of complication.

Comment	There is some evidence to suggest that not providing a restoration for a bounded edentulous space does not significantly increase loss of adjacent teeth[53].

Referees' Comments

We agree in principle with the comment that in bounded edentulous spaces there is an indication that teeth adjacent to a single tooth implant have a very low rate of complication. This statement will depend on the manner in which the tooth was lost. If the tooth loss was traumatic, damage sustained by the adjacent teeth must be evaluated. This will have particular relevance to ACC, where benefits are provided for accident related tooth loss. Implant placement must also be in such a position as not damage an adjacent tooth.

We agree in principle with the comment that there is some evidence to suggest that not providing a restoration for a bounded edentulous space does not significantly increase loss of adjacent teeth. In not restoring an edentulous space is the risk of mesial drift of adjacent teeth and over-eruption of opposing teeth is a concern. This shifting can result in later difficulty when restoring the edentulous space because of reduce inter arch space and a change in tooth contact positions increasing the risk of food impaction, gingivitis and interproximal caries. There is no suggestion here that advocates the non-replacement of missing anterior teeth with important aesthetic considerations.

Table 14. Effect of implants or the absence of a denture on adjacent teeth.				
Reference	***Design Score***	***Intervention***	***Number investigated***	***Key Results***
Shugars DA, et al 1998[53]	2-	Untreated, removable partial dentures and fixed partial dentures in patients with posterior bounded edentulous spaces (BES).	569 BES	Mean percentage failures of at least one tooth adjacent to a BES ranged from 12 to 19% (depending on database) in those patients who were untreated, 2 to 10% in those who had a fixed partial denture installed and 17 to 22% in those with a removable partial denture. An analysis of the data by separate database and when combined showed that the survival curves for teeth adjacent to a 'removable partial denture' and the untreated group were not significantly different from each other. Both were significantly different from the survival curve for the fixed partial denture group (p=0.009, p=0.01 respectively). Fixed partial dentures did result in a modest improvement in the survival of adjacent teeth. Given the selection bias introduced in using case series data, the extent to which treatment with fixed partial dentures improved tooth survival was not as dramatic as commonly assumed. The authors concluded that contrary to popular belief there was little evidence to support the idea that posterior BES should be restored to prevent loss of additional teeth.
Priest G 1999[54]	3	Single tooth implants. Role in preserving remaining teeth.	116	The author concluded that teeth adjacent to single tooth implants have an extremely low complication rate

1.14. Failure rates in the maxilla compared to the mandible.

Results

Seven studies were found that compared failure rates in the maxilla and the mandible including one meta-analysis (Table 15). The results of a meta-analysis[55] showed that the relative risk of failure in the maxilla compared to the mandible was greater than 3. These differences were of statistical significance but for partially edentulous patients or single crowns there was little difference. These results are similar to the conclusions in Esposito's review[12]. In one other cohort analysis[19] of case series data the failure rate in the maxilla was three times that of the mandible and this also was of statistical significance. In the DICRG study[10] there was no significant difference in the non-smokers and a difference of marginal significance in the smokers. In two other studies either no significant difference was found[11] or the difference was small and without an estimate of significance[33]. A study of the molar region showed that the difference in failure rates there was of marginal significance[56].

Discussion

The weight of evidence favours a higher rate of failure in the maxilla compared to the mandible but this is only seen when the mouth is fully edentulous and significant differences are not always observed. According to Cochran (1999)[55] in total edentulous arches success rates in the maxilla as low as 72.4% were reported. This compared to the lowest rate of 87.9% for the mandible. In such cases the absolute increase in risk of failure

in the maxilla is of such a magnitude that it could become a relevant factor influencing clinical judgement.

Comment	The failure rate of implants in the completely edentulous maxilla may be higher than that of the mandible and this may be of clinical significance and a relevant patient selection factor.

Referees' Comments

The literature supports the comment but may depend on whether implants have been placed in the anterior and/or posterior maxilla and whether implant placement is done in conjunction with a bone graft (sinus augmentation). Contributing risk factors previously identified may modify the success rate regardless of the arch placement.

Table 15. Implant survival in the mandible and the maxilla.

Reference	*Design Score*	*Intervention*	*Number of implants*	*Key Results*
Lambert PM, Morris HF, Ochi S 2000[10]	2+	Dental implants. Effect of smoking on implant failure.	1928 non smokers, 959 smokers	5.6% of all implants in the mandible of non smokers failed and 6.4% in the maxilla. The RR for failure, maxilla/mandible was 1.14 (95% CI, 0.80-1.63). The failure rate in the mandible for smokers was 6.9% and 10.9% in the maxilla. RR = 1.59, (95% CI, 1.04-2.41).
Eckert SE, Meraw SJ, Cal E, Ow RK 2000[11]	2-	Dental Implants, Branemark or ITI systems. Factors associated with fractured implants	4937	Implants fracture at similar rates in the maxilla and the mandible (0.6%).
Esposito M, Hirsch JM, Lekholm U, Thomsen P. 1998.[12]	2-	Dental implants (Branemark only). Effect of biological factors on implant failure. (data from several papers were aggregated).	8915 implants in totally edentulous subjects; 5174 in partially edentulous subjects	Failure in the maxilla was about 3 times that of the mandible except for the partially edentulous situation where there were similar rates of failure. No statistics were presented but data was aggregated to obtain means and percentages.
Minsk L, Polson AM, Weisgold A, et al. 1996[19]	2+	Dental implants, 70% Branemark, factors effecting implant failure.	1263	RR for failure in the maxilla compared to the mandible was 3.2 (95% CI 1.87-5.51)
Fiorellini JP, Chen PK, Nevins M, Nevins ML. 2000[33]	3	Factors influencing implant (Branemark, ITI) survival in diabetic patients (Type 1 and 2).	215	At a mean follow up of 4.1 years the success rates in the maxilla and mandible were 85.5% and 85.7%.
Cochran DL. 1999[55]	2+	Dental implants, survival analysed by jaw and type of implant (smooth surface, rough, hydroxyapatite). A meta-analysis.	See page 114	Relative risk for implant loss in the maxilla compared to the mandible was for rough surfaced implants, 3.24 (95%CI, 2.82-3.71, P< 0.001) and for smooth surfaced implants, 3.02 (95% CI, 2.80-3.25, P< 0.001). For subjects though that were partially edentulous, had single crowns or hydroxyapatite coated implants the differences were either marginally significant or not significant.
Becker W,	3	Implant (Branemark)	282	The 6 year cumulative success rates in molar positions of the maxilla

Table 15. Implant survival in the mandible and the maxilla.				
Reference	***Design Score***	***Intervention***	***Number of implants***	***Key Results***
Becker BE, Alsuwyed A, Al-Mubarak S 1999[56]		survival in in molar positions. Comparison of survival in the mandible and the maxilla.		and mandible were 82.9% and 91.5%. The authors believe this to be less than that observed for anterior segments. The relative risk of implant failure in the maxilla compared to the mandible in molar regions was 2.02 (95%CI, 1.02 - 3.98).

1.15. Failure rates in partially edentulous jaws

Results

Five studies were reviewed that investigated implant success rates in partially edentulous jaws (Table 16).

- A systematic review of 19 papers published up to 1998[57] concluded that success rates for implant supported fixed partial dentures and single crowns were comparable to that in completely edentulous arches
- An analysis[11] of a large case series concluded that the failure rate in partially edentulous situations was higher that seen in totally edentulous arches; But a semi-systematic review[12] of 73 papers drew the opposite conclusion.
- Two case series studies concluded that the differences in failure rates with jaw location for partially edentulous arches were not significantly different[58, 59].

Discussion

A review of Lindh's paper (1998)[57] from the 'Database of Abstracts of Reviews of Effectiveness'[60] has concluded that the data they presented was strong evidence for restoring partially edentulous arches using implants. If there is a difference in failure rate between partially and completely edentulous arches it is unlikely to be of clinical significance.

Suggested Recommendation	Implants placed in partially edentulous arches usually have acceptable failure rates.

Referees' Comments

The literature supports the comment that implants placed in partially edentulous arches usually have an acceptable failure rate. The comment may depend on whether implants have been placed in the anterior and/or posterior maxilla and whether implant placement is done in conjunction with a bone graft (sinus augmentation). Contributing risk factors previously identified may modify the success rate regardless of the arch placement.

Table 16. Studies in partially edentulous patients				
Reference	***Design Score***	***Intervention***	***Number of implants or papers***	***Key Results***
Eckert SE, Meraw SJ, Cal E, Ow RK 2000[11]	2-	Dental Implants, Branemark or ITI systems. Factors associated with fractured implants	4937	Implants fracture more frequently in partially edentulous restorations (1.5%) than in restorations of completely edentulous arches (0.2%).
Esposito M, Hirsch JM, Lekholm U, Thomsen P. 1998.[12]	2-	Dental implants (Branemark only). Effect of biological factors on implant failure.	8915 for totally edentulous patients, 5174 for partially edentulous	In partially edentulous patients the failure rate was about half that of totally edentulous subjects (3.8% cf 7.6%).
Lindh T, Gunne J, Tillberg A, Molin M 1998[57]	1-	Fixed partial dentures or single crowns, failure rate.	2686	Survival analysis showed an 85.7% success rate at one year for fixed partial dentures and 97.2% for single crowns. These rates were thought to be comparable to rates in completely edentulous jaws.
Eckert SE, Wollan PC, Ardekian L, Dodson TB. 1998[58]	3	Implants supporting fixed partial dentures in partially edentulous jaws (mostly Branemark)	1170	Implant survival in partially edentulous patients was independent of anatomic location. Statistical analysis was conducted but all results were non-significant.
Naert et al, 2002[59]	3	Implant (Branemark) and prosthesis survival in partially edentulous jaws. In 170 sites membranes or grafts were used.	1956	Cumulative survival rate was 91.4% for all implants and 95.8% for all restorations. The estimated hazard rate in the mandible was 0.66 that of the maxilla (95% CI, 0.42-1.03) but this was not significant.

1.16. Force concentration and implant failure

Results and Discussion

One study has reported that risk of implant failure after bone grafting is dependent in part on the opposing dentition[50] (Table 17). This may be a relevant patient selection factor. It would appear that opposing dentition that disperses the occlusal force is more likely to reduce the risk of implant failure in the maxilla and therefore efforts should be made to create a favourable occlusion in the mandible.

Comment	For implants in the maxilla after bone grafting (sinus augmentation), efforts should be made to create a favourable occlusion in the mandible that disperses the occlusal force; An inability to do so may increase the risk of implant failure.

Referees' Comments
We agree with the comment.

Table 17. Implant survival in the mandible and the maxilla.				
Reference	***Design Score***	***Intervention***	***Number of implants***	***Key Results***
Becktor JP, Eckert SE, Isaksson S, Keller EE. 2002[50]	3	Implants (Branemark) in the maxillae after bone grafting. Influence of opposing dentition on implant survival	643	Mandibular dentition that leads to force concentration on the implant predisposes to failure. Implants placed opposing unilateral occlusal support were 3.6 (95% CI, 1.3 – 9.7), 4.6 (1.1 – 19.2) and 12.3 (3.1 – 48.1) times more likely to fail than implants placed opposing either bilateral occlusal support, an implant supported prosthesis or a removable denture, respectively.

1.17. Anterior and posterior locations and implant failure

Results

Eight papers were found that investigated the effect of anterior/posterior location on implant survival or reported risk factors effecting survival in one of these locations (Table 18)

- A cases series paper[61] reported significantly higher failure rates in posterior locations
- Two other groups[26, 56] reported data that may be indicative of higher failure rates in posterior regions
- Two papers reported that the difference with location was either not significant[59] or reported a result indicative of a difference that was not clinically significant[33]
- Single tooth implants at anterior locations have a high rate of survival[62]
- Implants at posterior locations were significantly more mobile at placement[38]
- Survival of single tooth, hydoxyapaptite-coated implants in the anterior maxilla was correlated with implant length[62], and implant diameter and medical condition were risk factors for implant survival at posterior locations[52].

Discussion

Though some papers reported an increased risk of failure for implants in posterior locations others found no difference. It would appear that there is an inadequate evidence base to make any conclusion. Risk factors for failure at anterior or posterior locations have not been widely reported.

Comment	There is inadequate evidence to conclude that implant failure is greater at posterior locations compared to anterior.

Referees' Comments
The literature supports the comment that there is inadequate evidence to conclude that implant failure is greater in posterior locations compared to anterior, except in the situation where a maxillary sinus is grafted.

Table 18. Implant failure at posterior and anterior locations.				
Reference	***Design Score***	***Intervention***	***Total number of implants***	***Key Results***
Keller EE, Tolman DE, Eckert SE 1999[26]	3	Dental implant after maxillary antral-nasal autogenous bone graft reconstruction of compromised maxilla. Risk factors influencing survival.	248	A patient selection factor for risk of failure was molar site. The failure rate for molars, premolars and anterior locations were respectively 15.3%, 13.5% and 10.6%. No statistics were presented.
Fiorellini JP, Chen PK, Nevins M, Nevins ML. 2000[33]	3	Factors influencing implant (Branemark, ITI) survival in diabetic patients.	215	For the anterior and posterior regions the success rates were respectively 83.5% and 85.6%. Significance not stated.
Orenstein IH, Tarnow DP, Morris HF, Ochi S 1998[38]	2-	Mobility of the implant at time of placement. Factors related to this	2641	A patient selection variable associated with mobility at placement was anterior-posterior jaw location, with posterior locations slightly more likely to be mobile (p=0.032);
Attard NJ, Zarb GA, 2003[52]	3	Implants (Branemark) in posterior positions. Implant outcome and host determinants.	432	Implant survival in posterior locations was correlated with implant diameter (p=0.0001) and medical condition (p=0.01). The authors concluded that implant supported fixed partial dentures were a suitable treatment option for replacing posterior teeth.
Becker W, Becker BE, Alsuwyed A, Al-Mubarak S 1999[56]	3	Implant (Branemark) survival in molar positions. Comparison of survival in the mandible and the maxilla.	282	At a mean follow up of 3.9 years the cumulative success rates in the maxilla and mandible molar positions were 82.9% and 91.5%. The authors believe this to be less than that observed for anterior segments.
Naert et al, 2002[59]	3	Implant (Branemark) and prosthesis survival in partially edentulous jaws. In 170 sites membranes or grafts were used.	1956	The effect of location within the jaw (anterior v. posterior) on implant survival was not significant (p = 0.85).
Scurria MS, Morgan ZVt, Guckes AD, Li S, Koch G. 1998[61]	3	Dental implant survival rate; Factors related to survival.	384	Failure was significantly associated with posterior locations (p<0.05). Failure rates in the anterior and posterior mandible, and in the anterior and posterior maxilla were respectively 6.4%, 13.2%, 9.1% and 16.3%.
Orenstein IH, Petrazzuolo V, Morris HF, Ochi S 2000[62]	3	Single tooth hydroxyapatite coated implants in anterior maxillae. Survival analysis.	222	The survival rate was 97.3% and correlated with implant length (p=0.003). The authors' concluded that the use of hydroxyapatite coated implants to support maxillary anterior single tooth implants is a reliable and predictable procedure.

1.18. Age and implant failure

Results

Four studies were found that reported on the effect of age on bone loss around the implant or on implant failure and two consensus documents referring to the effect of age were reviewed (Table 19).

- The DICRG study[10] found that age was not associated with implant failure and this result was supported by a case series study[58] in partially edentulous patients
- A case series study[28] found no association between bone loss around the implant and age
- A study of implant mobility at placement reported that age was an associated factor[38].
- A survey of dentist opinion[29] and a consensus guideline from the Faculty of Dentistry, Royal College of Surgeons[30] both conclude that age is not an important variable associated with implant failure. It was suggested though that implants should be delayed in young individuals until growth is complete.

Discussion

Though the weight of evidence is light it is consistent. It is concluded that age in most circumstances is not a relevant risk factor for implant failure.

Suggested Recommendation	Providing there was good life expectancy, age is not generally considered a risk factor for implant failure but implants should be delayed in young individuals until growth is complete.

Referees' Comments

We agree with the comment that providing there is good life expectancy, age is not generally considered a risk factor for implant failure but implants should be delayed in young adults until growth is complete.

The literature reports are mixed regarding the recommendations for placing implants in individuals under 20 years of age [20]. There are several concerns that need to be considered when considering osseointegrated implants in jaws that are still growing [21]. These include: i. Implants behave like an ankylotic tooth and they don't move during growth and development so there is a risk of the implant becoming embedded, relocated or displaced as the jaw grows; ii. An implant supported fixed prosthesis may have a negative influence on the local growth and development of the dento-alveolar processes; iii. What is the best time to place an implant in a young adult? A general, but not universal recommendation is that dental implants not be placed before all the permanent teeth have erupted or before the age of 16 years. There are a number of papers in the literature that advise against placing dental implants during the growing period, which can be into the late teens for females and early twenties for males. However, there is no definitive correlation between chronologic patient age and completion of jaw growth. This makes it difficult to determine what age is suitable on an individual basis because while the anterior maxilla is a cosmetically sensitive area, the potential for continued maxillary down growth away from the base of the skull means that if implants are placed too soon it may be necessary to plan for the need to replace the implant in 5 years or less. This replacement would be necessary for cosmetic reasons, such as the crown being in infra-occlusion due to continued maxillary growth [22]. The advantage of early placement of a dental implant is the possible elimination of the need for bone grafting [23]. This must be weighed against technical disadvantages such as a poor implant to crown ratio, the need for early replacement of the crown or a possible block osteotomy to reposition the implant which behaves like an ankylosed tooth [20] . More recent recommendations are that implants should not be placed until somatic growth is complete (age 17 year for female and age 20 for male) with a relatively reliable age for implant placement being 19 years for female and 21 years for males (Melsen, 2003). When placing implants in a young adult, the following ethical aspects should be considered [24] : i. The treatment should be performed in the best interests of the patient; ii.

The treatment should be preceded by thorough discussion and approval from the patient and parents; iii. The treatment should be performed by specialists; iv. The treatment should be thoroughly documented by long-term follow-up.
In summary, at this time there is no clear consensus on the minimum suitable age to place an implant in the young adult, but the recommendations of Melsen appear to be reasonable selection criteria.

Table 19. Effect of age on implant failure rates.

Reference	*Design Score*	*Intervention*	*Total number of implants*	*Key Results*
Lambert PM, Morris HF, Ochi S 2000[10]	2+	Dental implants. Effect of smoking on implant failure.	2887	There was no significant association of failure with age in all subjects
Nosaka Y, Tachi Y, Shimpuku H, Kawamura T, Ohura K 2002[28]	3	Dental implantation (Astra Tech AB, Molndal Sweden). Calcitionin receptor gene polymorphism - effect on marginal bone loss after implantation but before adding of the prosthesis.	237	Bone loss was not effected by age.
Heinikainen M, Vehkalahti M, Murtomaa H. 2002[29]	4	Dental implants, opinion survey of risk factors		Age was not generally considered an important factor to decline implantation.
Anonymous, Faculty of Dentistry, The Royal College of Surgeons. England, 1997[30].	4	Dental implants. Patient selection factors. Consensus guideline.		Providing there was good life expectancy there was no upper age limit. Implants should be delayed in young individuals until growth is complete.
Orenstein IH, Tarnow DP, Morris HF, Ochi S 1998[38]	2-	Mobility of the implant at time of placement. Factors related to this	2641	A patient selection variables associated with mobility at placement was age (p=.05) with the lowest percentage of mobile implants occurring in the young
Eckert SE, Wollan PC, Ardekian L, Dodson TB. 1998[58]	3	Implants in partially edentulous jaws (mostly Branemark)	1170	Implant survival in partially edentulous patients was not significantly effected by age.

2. Patient satisfaction

2.1. Conventional dentures v. mandibular implant retained dentures

Results

One systematic review, 3 RCTs and five other papers were reviewed that included patient satisfaction with conventional mandibular dentures compared to implant retained dentures (Table 20).

- The systematic review included 3 RCTs published before 1998 and one crossover study. According to Locker (1998)[8] the RCTs indicated that implant retained mandibular dentures compared to conventional dentures improved chewing ability and patient satisfaction but improvements in quality of life were not demonstrated
- Two RCTs published since 1998[63, 64] each concluded that implant supported dentures improved patient satisfaction. Awad et al's study (2003)[63] made their comparison only 2 months after placement. In Raghoebar's et al (2000) study[64] of patients with severely resorbed mandibles, the degree of statistical significance was more marginal at one year and five years post placement. Raghoebar proposed a strategy where by patients with

still relatively high mandibular bone would receive a complete denture first and if dissatisfied at one year would have the opportunity to have implants

- A third RCT[65] where patient satisfaction was compared in diabetics found no statistical difference
- A case-control study[66] compared quality of life with oral condition for mandibular fixed partial dentures compared to no denture or a removable denture. They found significant improvements with the fixed partial denture compared to the other two states
- Three case series studies[67-69] all reported improved patient satisfaction with installation of the implant supported dentures compared to the previous conventional denture
- A consensus conference[1] concluded there was overwhelming evidence that a 2-implant overdenture should become the first choice of treatment for the edentulous mandible regardless of attachment system used.

Discussion

The McGill Consensus conference[1] has made a strong recommendation in favour of implant retained overdentures, however the published evidence is not unequivocal. Locker[8] in his systematic review found the quality of evidence to be relatively poor and made a suitably cautious conclusion as did Raghoebar[64]. The study in diabetic patients found no statistically significant difference in patient satisfaction[65]. Awad et al[70] was the only RCT to report evidence in favour of implants of high statistical significance but the comparison was made only two months after treatment.

There is some evidence then, that in the mandible, implant retained dentures give a variably increased margin of patient satisfaction in some patients over that of conventional dentures.

Suggested Recommendation	Two - implant supported overdentures are a satisfactory treatment for edentulous patients with problems with their lower denture. In most patients it is recommended that a conventional denture be trialled first for one year[64, 65].

Suggested Recommendation	In patients with severely resorbed edentulous mandibles, implant supported prostheses may be the treatment of choice[64].

Referees' Comments

The literature supports the comment that two-implant supported over dentures are a satisfactory treatment for edentulous patients with problems with their lower denture. In most patients it is recommended that a conventional denture be trialed first for one year. While it may be necessary to commence implant-supported overdenture treatment earlier than one year in some patients, waiting for up to a year means that for some patients the support and retention obtained from implants may not be necessary, saving the cost of additional treatment and maintenance. The advantages of making a conventional denture first include the ability to assess the patient, and a duplicate of the denture can be used as a radiographic and surgical guide stent.

The literature supports the comment that in patients with severely resorbed edentulous mandibles, implant supported prostheses may be the treatment of choice.

Table 20. Patient satisfaction: Comparison of conventional mandibular dentures and implant retained dentures.				
Reference	***Design Score***	***Intervention***	***Total number of papers reviewed or patients***	***Key Results***
Feine et al 2002[1]	4	Mandibular 2-implant overdentures compared to conventional dentures		The symposium concluded there was overwhelming evidence that a 2-implant overdenture should become the first choice of treatment for the edentulous mandible regardless of attachment system used.
Locker D. 1998[8]	1+	Patient satisfaction with dental implants compared with conventional dentures. The crossover trial and 3 RCTS compared satisfaction with mandibular systems.	19 studies including 1 crossover and 3 RCTs	The author concluded that the RCTs indicate that (mandibular) implant supported systems improve chewing ability and satisfaction with dentures but have not demonstrated effects with respect to quality of life.
Awad MA, Lund JP, Dufresne E, Feine JS, 2003; and Awad M et al, 2000.[63, 70]	1+	Edentulous patients who had worn conventional dentures for at least 10 years were studied. Mandibular overdentures supported on 2 implants (Branemark) or conventional mandibular dentures were compared. Both groups received a new set of conventional maxillary dentures as well. Comparison of patient satisfaction.	102	At 2 months after delivery of the prosthesis general satisfaction was significantly higher in the implant group ($p<0.0001$). On average the implant group rated satisfaction 26.5mm higher (on 100mm VAS scale). The implant group also rated satisfaction higher for comfort, stability, and ease of chewing ($p<0.05$) but there was no difference with respect to ease of cleaning, ability to speak, or aesthetics. The authors concluded that mandibular 2 implant overdentures opposed by maxillary conventional dentures were more satisfactory than conventional dentures for edentulous middle aged adults. The Oral Health Impact Profile scores were significantly lower post treatment in the implant compared to the conventional group indicating a better quality of life outcome ($p<.0.05$).
Raghoebar G et al. 2000[64]	1-	In patients edentulous in the mandible and in whom the mandible was severely resorbed, patient satisfaction was studied with one of three treatment options; conventional dentures, conventional dentures after preprosthetic surgery and implant (Branemark or IMZ) retained mandibular overdentures. All patients received a new maxillary denture.	90	After one year those with conventional dentures had scored significantly lower satisfaction scores than in the other two groups for most items surveyed ($p<0.05$). At five years those with implant retained overdentures scored significantly better with respect to 'complaints with the lower denture' compared to those with conventional dentures ($p<0.05$) but there was no significant difference in overall patient satisfaction. The authors' concluded that implant supported overdentures were the treatment of choice for patients with resorbed edentulous mandibles. They proposed a strategy where by patients with still relatively high mandibular bone would receive a complete denture first and if dissatisfied at one year would have the opportunity to have implants.
Kapur K et al. 1998[65]	1-	In edentulous diabetic patients conventional mandibular dentures were compared to implant supported overdentures (plastic clip retainers for a Hader bar attached to 2 IMZ implants). Patients also received a new set of maxillary dentures. Comparision of patient satisfaction	89	Treatment was judged successful in 56.9% of those receiving conventional dentures and 72.1% of those with implants but this difference was not statistically significant. The authors concluded that the implant-supported overdenture has some advantage in terms of perceived chewing function. The authors' concluded that implant supported mandibular overdentures may be considered when patients continue to experience chronic problems with clinically acceptable conventional dentures.
Kuboki T,	2-	Patients with unilateral	60	Quality of life questions assessing oral condition (functional

Table 20. Patient satisfaction: Comparison of conventional mandibular dentures and implant retained dentures.				
Reference	***Design Score***	***Intervention***	***Total number of papers reviewed or patients***	***Key Results***
Okamoto S, Suzuki H, et al 1999[66]		mandibular distal-extension edentulism. Quality of life assessment with respect to oral condition and general condition was compared in three groups of patients; those with implant (IMZ) supported fixed partial dentures (FPD), removable partial dentures (RPD) and those with no restoration (NR).		limitation, physical pain/discomfort and anxiety) were scored higher by those with fixed partial dentures on dental implants (92.5, 96.3,92.2) than by those with either removable partial dentures (80.3,80.6,78.1) (P=0.006, 0.0003, 0.0058) or no restoration (79.0, 79.6, 78.6)(p= 0.0063, 0.0029, 0.008). There were no significant differences between the removable partial denture group and the no restoration group. The authors concluded that implant supported fixed partial dentures may promote quality of life with respect to oral condition.
de Albuquerque Junior RF, Lund JP, Tang L, et al. 2000[67]	3	New conventional maxillary and mandibular dentures were trialled in totally edentulous patients for a 2 month period. This was followed by installation of 4 maxillary implants, 4 mandibular implants (Branemark Implants) and a healing period. A fixed mandibular prosthesis was then installed and trialled for a 2 month period against conventionl maxillary dentures. Maxillary long-bar overdentures with and without palate were then trialled for 2, 2 month periods in a cross over design. A comparison was made of patient satisfaction.	16	Ratings for mandibular prostheses increased when new conventional dentures were replaced with implant prostheses and opposed by conventional maxillary dentures (p = .032). Significant increases in stability (p<0.0001) and retention (p=0.002) also occurred but conventional dentures were considered easier to clean (p=.003).
Walton Jn, MacEntee M. I. Glick N. 2002[68]	3	Comparison of mandibular dentures retained with either ball or clip on 2 implants (Branemark). And comparison with conventional dentures. Patient satisfaction.	64	Patient's preferred ball or clip prostheses to the previous conventional denture (p<0.001).
Leung AC, Cheung LK. 2003[69]	3	Dental implants in the maxilla or mandible. (Branemark, IMZ, Calcitek) after bone grafting. Patient satisfaction with treatment.	28	Overall satisfaction was high (greater than 8/10) for a range of variables including appearance and function. Satisfaction was not related to age, jaw or gender.

2.2. Patient satisfaction with conventional dentures after preprosthetic surgery v. dental implants

Results

Only one study was found that compared patient satisfaction with conventional dentures after preprosthetic surgery[64] and dental implant supported prostheses (Table 21). Patient satisfaction was greater to a modest degree at one year in favour of implants and also at 5 years depending on the basis of the comparison.

Discussion

A Cochrane review of this paper[2] concluded that there was weak evidence that patients are generally less satisfied with conventional dentures after preprosthetic surgery than with dentures retained by implants. However any differences were only seen at one year and not in the longer term on an 'intention to treat basis'. It is concluded that the evidence is weak that dental implants are preferable to preprosthetic surgery followed by conventional dentures, for patients with severely resorbed mandibles.

Comment	There is weak evidence that dental implants are preferable to preprosthetic surgery followed by conventional dentures, for patients with severely resorbed mandibles.

Referees' Comments

In reviewing the literature, it appears that there is weak evidence that dental implants are preferable to pre-prosthetic surgery followed by conventional dentures, for patients with severely resorbed mandibles. The use of implants to support prostheses is widely regarded to have completely eclipsed the pre-prosthetic surgical techniques for improving support for dentures [25]. For this reason there are relatively few papers available that compare the two techniques. We would recommend relying on the suggested recommendations 1 and 2 in part 2.1.

Table 21. Patient satisfaction with conventional dentures after preprosthetic surgery versus dental implants

Reference	*Design Score*	*Intervention*	*Total number of papers or patients*	*Key Results*
Coulthard P, Esposito M, Worthington HV, Jokstad A. 2003[2]	1-	Studies on patients receiving preprosthetic surgery to modify the oral anatomy and facilitate the retention of conventional dentures compared to osseointegrated implants to improve denture retention	1 paper was reviewed.	There was weak evidence that patients are generally less satisfied with conventional dentures after preprosthetic surgery than with dentures retained by implants.
Raghoebar G et al. 2000[64]	1-	In patients edentulous in the mandible and in whom the mandible was severely resorbed, patient satisfaction was studied with one of three treatment options; conventional dentures, conventional dentures after preprosthetic surgery and implant (Branemark or IMZ) retained mandibular overdentures. All patients received a new maxillary denture.	90 patients	At one year those receiving implants were more satisfied than those having preprosthetic with respect to complaints with the lower denture and problems with chewing tough and hard foods; Overall patient satisfaction was not different between the implant and preprosthetic surgery groups though. At 5 years there was no significant difference between the 2 groups for any factor.

2.3. Patient satisfaction with implant retained dentures in the maxilla v. conventional dentures

Results

Four studies were reviewed that investigated patient satisfaction with implant supported prosthesis in the maxilla (Table 22). (Locker (1998)[8] in his systematic review found no RCT studies reporting on patient satisfaction with maxillary implant supported dentures).

- Conventional dentures in the maxilla[67] did not give less satisfaction than implant retained overdentures. The authors' concluded that in the maxilla implant supported prostheses should not be considered a general treatment of choice in patients with sufficient bony support for conventional prostheses
- Two other case series studies[69, 71] considered that patient satisfaction with maxillary implants was acceptable, including aesthetic satisfaction with anterior single tooth implants[71]
- Patients with atrophic maxillae also had acceptable patient satisfaction scores after receiving implants after bone grafting[72].

Discussion

Complete denture wearers are usually able to wear upper dentures without problems[1] and the research on patient satisfaction with implants tends to be dominated by studies of the mandible. In this review no sophisticated studies were found that compared satisfaction with conventional dentures in the maxilla and implant retained dentures.

Suggested Recommendation	In patients with sufficient bony support in the maxilla, conventional prostheses are usually the treatment of choice [67].

Referees' Comments

We agree in principle with the comment that in patients with sufficient bony support in the maxilla, that conventional dentures are usually the treatment of choice. I would again recommend referring to suggested recommendations 1 and 2 in part 2.1.

Table 22. Patient satisfaction with implant retained prostheses in the maxilla.

Reference	*Design Score*	*Intervention*	*Total number of patients*	*Key Results*
de Albuquerque Junior RF, Lund JP, Tang L, et al. 2000[67]	3 and 2-depending on phase of trial.	New conventional maxillary and mandibular dentures were trialled in totally edentulous patients for a 2 month period. This was followed by installation of 4 maxillary implants, 4 mandibular implants (Branemark Implants) and a healing period.. A fixed mandibular prosthesis was then installed and trialled for a 2-month period against conventionl maxillary dentures. Maxillary long-bar overdentures with and without	15	There were no significant differences in general satisfaction between the 3 maxillary prostheses trialled including the rating of general satisfaction between maxillary overdentures with and without palatal covering. The authors concluded that maxillary implant prostheses should not be considered as a general treatment of choice in patients with sufficient bony support for maxillary

Table 22. Patient satisfaction with implant retained prostheses in the maxilla.				
Reference	***Design Score***	***Intervention***	***Total number of patients***	***Key Results***
		palate were then trialled for 2, 2-month periods in a cross over design. A comparison was made of patient satisfaction.		conventional prostheses.
Leung AC, Cheung LK. 2003[69]	3	Dental implants in the maxilla or mandible. (Branemark, IMZ, Calcitek) after bone grafting. Patient satisfaction with treatment.	28	Overall satisfaction was high (greater than 8/10) for a range of variables including appearance and function. Satisfaction was not related to age, jaw or gender.
Chang M, Odman PA, Wennstrom JL, Andersson B 1999[71]	3	Patient satisfaction with single tooth implants and abutment (Branemark) in the maxillary anterior region.	29	Appreciation with the aesthetic outcome was rated highly; All variables assessed (eg crown form, colour, satisfaction with appearance) rated greater than 90% satisfaction.
Kaptein ML, Hoogstraten J, de Putter C, de Lange GL, Blijdorp PA. 1998[72]	3	Patients with atrophic maxilla. Maxillary bone reconstruction followed by dental implants (IMZ). Patient satisfaction with reconstruction and implant.	88	Patients scored their total treatment 4.1 out of 5, a score the authors considered acceptable.

2.4. Patient satisfaction with various implant systems (Table 23)

Results and Discussion

Four RCTs and three other studies of lower design quality were reviewed that compared patient satisfaction with various implant systems.

- Two RCTs have reported on patient satisfaction with mandibular prostheses retained by various systems. Patient satisfaction with prostheses retained by a bar-clip or ball was greater than with those retained by a magnet[73] but ball systems have high maintenance costs[68]. With respect to patient satisfaction alone there is little difference between bar and ball systems[68, 73]. While the bar system has the highest retention characteristics and least complications[73] there are sometimes other clinical complications to be considered
- From a therapeutic perspective, results of an RCT show that there are only minor differences between the 2-stage Branemark system and the 1-stage ITI system[74] but patients report difficulty with the surgery associated with the 2-stage Branemark system
- An RCT[75] has concluded that patient satisfaction was lower for the IMZ system compared to the Branemark system
- A case-control study[76] has concluded that there is no difference in patient satisfaction for patients with bounded edentulous spaces who had either a resin-bonded prosthesis or an implant supported prosthesis.
- A case control study[77] has concluded that maxillary implant retained long-bar overdentures appear to provide patients with better speech function and are easier to clean than implant retained fixed prostheses.
- A crossover study[67] has shown that there appears to be little difference in patient satisfaction between implant supported maxillary long-bar overdentures with a palate covering and without the covering.

Comment	Patient satisfaction is comparable with prostheses retained in the mandible on implants using either ball or bar-clip systems.

Comment	There is some evidence (one study) that in the maxilla long bar overdentures with a palatal covering have similar patient satisfaction ratings to systems without a palatal covering.

Comment	There is some evidence (one study) that patient satisfaction with 'implant retained removable overdentures on a long parallel bar' in the maxilla is higher than with a fixed prosthesis.

Comment	In patients with bounded edentulous spaces there is some evidence (one study) that patient satisfaction is similar for resin bonded fixed prostheses and implant supported prostheses.

Referees' Comments

The literature supports the comment that patient satisfaction is comparable with prostheses retained in the mandible on implants using either ball or bar-clip systems.

The following comments are offered for consideration Regarding the final comment, we would note that resin-bonded bridges have variable success and are very technique sensitive. Success rates vary between 34.9% [26] to 92.9% [27]. Following certain guidelines and bonding using meticulous resin-bonding technique can improve the success rate of resin bonded bridges [28-37]. Failure to properly treatment plan and follow meticulous technique can result in early failure of these bridges. Successful long-term rebonding of the bridge is more difficult because the fitting surface of the bridge needs to be reprepared and the palatal tooth surface is more difficult to prepare for resin bonding because of the previous resin bonding tooth preparation. Palatal tooth preparation is irreversible and must be restored if or when an implant retained prosthesis is subsequently placed. Finally cosmetics with these bridges can be compromised with a gray appearance to the abutment tooth or teeth from the underlying metal of the bridge; this is not a complication when a fibre reinforced resin bonded composite bridge is used.

Table 23. Patient satisfaction with implant systems

Reference	*Design Score*	*Intervention*	*Total number patients*	*Key Results*
de Albuquerque Junior RF, Lund JP, Tang L, et al. 2000[67]	2- and 3 depending on phase of trial.	New conventional maxillary and mandibular dentures were trialled in totally edentulous patients for a 2 month period. This was followed by installation of 4 maxillary implants, 4 mandibular implants (Branemark Implants) and a healing period.. A fixed mandibular prosthesis was then installed and trialled for a 2-month period against conventionl maxillary dentures. Maxillary long-bar overdentures with and without palate were then trialled for 2, 2 month periods in a cross over design. A	16	There were no significant differences in general satisfaction between the 3 maxillary prostheses trialled including the rating of general satisfaction between maxillary overdentures with and without palatal covering.

Table 23. Patient satisfaction with implant systems				
Reference	***Design Score***	***Intervention***	***Total number patients***	***Key Results***
		comparison was made of patient satisfaction.		
Walton Jn, MacEntee M. I. Glick N. 2002[68]	1-	Comparison of mandibular dentures retained with either ball or bar clip on 2 implants (Branemark). Patient satisfaction.	64	Ball attachments required about 8 times longer to repair than bar clip prostheses ($p<0.001$) and repair was required more often ($p<0.01$). There was no difference in patient satisfaction with either ball of clip mechanisms at one year.
Naert I et al, 1999[73]	1-	Mandibular overdentures retained on one of 3 systems (ball, magnet and bar (Dolder bar with continuous clip)) on Branemark implants	36	The bar retained mandibular overdentures had the highest retention capacity and least prosthetic complications but caused more mucositis and gingival hyperplasia. Patient satisfaction was good with all groups but the magnet group because of lower retentive capacity scored prosthesis stability and chewing comfort lower ($p<0.05$) and general satisfaction and denture stability lower ($p<0.03$).
Moberg LE, Kondell PA, Sagulin GB, Bolin A, Heimdahl A, Gynther GW. 2001[74]	1-	Comparison of patient satisfaction etc with mandibular fixed prosthesis on the 2 stage Branemark system or the 1 stage ITI system.	40	About half of the Branemark patients reported difficulty in coping with the surgical procedures. From a therapeutic perspective there were only minor differences between the 2 systems.
Meijer Hj, Geertman M. E. Raghoebar G. M. Kwakman J. M. 2001[75]	1-	Patients edentulous with severely resorbed mandibles Implant retained mandibular overdentures using 3 systems: IMZ (Intra Mobiele Zylinder), Branemark or TMI (Transmandibular Implant) in patients with severely resorbed mandibles. Patient satisfaction with system.	87	At 6 years patient satisfaction was least for the IMZ system (7.7) compared to a score of 8.4 for the Branemark system. The difference was significant ($P<0.05$). (Data on TMI system not included here)
Sonoyama W, Kuboki T, Okamoto S, et al. 2002[76]	2-	Patients with bounded edentulous spaces who had either a resin-bonded prosthesis or an implant supported prosthesis. Comparison of quality of life.	44	The mean QOL scores measuring 'oral condition' were 87.8 and 87.1 in the implant supported and resin-bonded groups respectively. Mean 'general condition' scores were respectively 73.8 and 71.6. Neither of these differences were significant. The authors concluded that in patients with bounded edentulous spaces, quality of life scores do not differ between those with implant supported fixed prostheses and those with resin bonded fixed prostheses over a short follow up period.
Heydecke G, 2003[77]	2-	Patient satisfaction with maxillary implant retained (4 to 6 implants, Branemark) fixed prostheses (FP) compared to implant retained removable overdentures on a long parallel bar (LBO). These were opposed by mandibular implant - supported overdentures.	13	Removable long-bar overdentures received higher ratings of general satisfaction than fixed prostheses ($p=0.003$), and also scored, ability to speak ($p=0.036$) and ease of cleaning higher ($p=0.004$). The authors concluded that the long-bar overdentures appear to provide patients with better speech function and are easier to clean than fixed prostheses.

3. Comparison of costs of implant and other systems

Results

Four papers were reviewed that studied the costs of various implant systems and compared them with other systems (Table 24).

- Total costs of conventional mandibular dentures were about one-third that of implant retained dentures or dentures after preprosthetic surgery and about one-seventh the cost of transmandibular implants[78]
- Mandibular implants supporting a removable prosthesis initially cost about one half that of a fixed prosthesis but have higher follow up costs[79]
- In patients with bounded edentulous spaces resin bonded systems over the first year cost about one-seventh of an implant supported fixed prostheses[76].
- For the mandible, clip attachment systems appear to have lower maintenance costs than ball systems[68].

Discussion

There are only a few studies that have compared the costs of various denture systems. While the four studies reviewed did not use New Zealand data it would appear that the cost of conventional mandibular dentures and resin bonded dentures in bounded edentulous spaces are much cheaper than implant retained systems. Removable mandibular prostheses on implants are at least initially cheaper than fixed prostheses.

Comment	Conventional dentures in the mandible and 'resin bonded dentures in bounded edentulous spaces' are much cheaper than implant retained systems.

Referees' Comments

From both an economic perspective and from a risk/benefit perspective, we would support the comment that conventional dentures in the mandible and resin bond bridges in the bounded edentulous spaces are much cheaper than implant retained systems. This comment does not preclude the implementation of "more expensive" treatment options bases on appropriate patient selection criterion.

Table 24. Summary of papers reviewing and comparing costs of 'implant retained' and other systems.

Reference	*Design Score*	*Intervention*	*Total number of patients*	*Key Results*
Sonoyama W, Kuboki T, Okamoto S, et al. 2002[76]	2-	Implant supported fixed prosthesis, and resin-bonded fixed prosthesis; Comparison of quality of life. Japanese study lasting from 1 to 2 years depending on group.	44	Average cost of the implant supported prosthesis was $US2236 compared to $US296 for the resin-bonded group.
van der Wijk P, Bouma J, van	1+	Mandibular overdentures supported on 2 dental	240	Total costs over one year for transmandibular implants, standard implants, preprosthetic surgery + complete

Waas MA, van Oort RP, Rutten FF. 1998[78]		implants (Branemark, IMZ) compared to transmandibular implants, conventional dentures after preprosthetic surgery and conventional dentures. All patients received a new set of maxillary dentures. Cost comparison study. A Dutch study.		dentures, and complete dentures were respectively $7605 - $8830, $3711, $3808 and $1205. Cost of transmandibular implants were about 7 times that of conventional dentures and standard implants about 3 times. New dentures after preprosthetic surgery are almost as expensive as implants. The authors considered their analysis to be robust as assessed by sensitivity analysis.
Tinsley D, Watson CJ, Russell JL. 2001[79]	1-	Comparison of initial and follow up costs, visits, work time and complications of placing mandibular implants (Calcitek, hydroxyapatite coated implants) that supported a fixed or removable prostheses in the mandible. A 6 year English trial.	48	Over a six-year period, implant failure rates were similar. Clinical time taken to construct the prosthesis was similar for the two groups, but the removable restoration cost less than half that of the fixed prosthesis when technical time and material costs were considered. Patients with removable dentures required more visits over the six years and the incidence of remakes and adjustments was also higher. The authors' concluded that overdentures offer an effective and initially a more economical alternative to the fixed prosthesis. However longterm maintenance can be significant.
Walton Jn, MacEntee M. I. Glick N. 2002[68]	1-	Comparison of mandibular dentures retained with either ball or bar clip on 2 implants (Branemark). Patient satisfaction.	64	Ball attachments required about 8 times longer to repair than bar clip prostheses ($p<0.001$) and repair was required more often ($p<0.01$). There was no difference in patient satisfaction with either ball of clip mechanisms at one year.

Further Discussion

Additional reports

In addition to the above studies, inclusion/exclusion criteria for patient selection used or suggested by two major groups are given below for comparison.

In 1988 the NIH organised a consensus development conference[80] to assess the medical knowledge at that time for dental implantology. Contraindications listed relevant to patient selection were ;

- Debilitating or uncontrolled disease
- Pregnancy
- Conditions, diseases, or treatments that severely compromise healing, eg., radiation therapy
- Poor patient motivation
- Psychiatric disorders that interfere with patient understanding and compliance with necessary procedures
- Unrealistic expectations
- Unattainable prosthodontic reconstruction
- Inability of patient to manage oral hygiene
- Patient hypersensitivity to specific components of the implant.

The conference reported that patient selection should be based on a survey to verify adequate bone structure, medical history, medical laboratory studies, consultation with the patient's physician and a psychosocial appraisal when psychological symptoms are present. Children needed special consideration given the long-term morbidity considerations, requirements for growth, manual dexterity and coping skills.

The Dental Implant Clinical Research Group (1992)[81] for their studies used the following criteria (Table 25) as the basis to possibly exclude patients from receiving an implant.

Table 25. Medical/Dental Problems that may Preclude Participation
1. Any medical conditions that would limit the life expectancy of the patient: a. Terminal illness b. Immunocompromised disorders c. Leukaemia d. Collagen disorders (ie. Lupus erythematosis, scleroderma, etc.) e. Compromised physical status
2. Medical conditions that may preclude extensive dental treatment because such treatment could present a hazard either to the patient or to the dentist: a. Insulin-dependent diabetes b. Long-term steroid therapy c. Radiation therapy to potential implant site d. Anticoagulants e. Viral hepatitis f. Haemodialysis g. Severely disturbed psychiatric patient h. Heart surgery within last 6 months i. Chronic nephritis
3. Medical, psychological and behaviour patterns that would limit the usefulness of the treatments to the patient or the assessment of the results with respect to the treatment: a. Severe physical handicap affecting manual dexterity b. Mental incompetence c. Substance abuse d. Extreme and unrealistic expectations of aesthetics and/or functional results e. Poor motivation f. Metabolic disorders g. Severely over or under weight
4. Dental conditions that may preclude participation in the study: a. Poor oral hygiene b. A history of acute necrotizing ulcerative gingivitis c. Temporomandibular joint (TMJ) disorder d. Bruxism e. Pain or soreness in jaws or face f. Numbness or prickling sensation in mouth g. Any infections in the mouth h. Prior history of broken jaw or face.

Additional comments

From a clinical perspective the use of implants to retain dentures or crowns in uncomplicated situations appears to be a successful and safe intervention. If appropriateness is defined as the relative weight of benefits and harms then dental implants are often appropriate interventions.

Appropriateness in a broader context though, not only refers to the consideration of benefit to risk but also to the anticipated increased benefit over alternative interventions in the light of such factors as cost, patient satisfaction and availability of services. The alternatives to dental implants are the conventional prostheses which are cheaper and in some circumstances deliver equivalent satisfaction to the patient.

Based on overseas data it would appear that the cost of implants is about three times that of conventional dentures and the cost of resin bonded fixed prostheses in bounded edentulous spaces about one-seventh that of an implant retained system. In a cost constrained health system, such as in New Zealand, it is reasonable to suggest that the increased degree of patient satisfaction obtained be considered in the light of the increased cost. It is suggested that for uncomplicated situations more conservative, less costly options are often the most appropriate.

Further possible steps towards guideline development.

Since the weight of evidence for the use of implants in given situations is often light, guideline development will be dependent on establishing a synthesis of available evidence and the collective judgement of a panel of experts to derive best practice.

If a best practice guideline is to be developed some additional steps may be required. These are;

- Peer review by dental specialists and modification of this review
- Development of a list of clinical scenarios or indications which categorise patients in terms of their dental presentation, lifestyle, medical history and other relevant factors
- Development of an expert panel including consumers to review the evidence, hear expert opinion and make decisions on appropriateness with respect to the scenarios
- Development of a best practice guideline including clinical decision aids.

Conclusions

It is concluded that dental implants are a successful intervention that typically have success rates of greater than 90% over the longer term, in university settings. In uncomplicated situations, it is proposed that an implant-retained system is not an appropriate first line of intervention for tooth loss in either the mandible or the maxilla. In

most cases a conventional denture, resin-bonded system or other similar alternative, should be trialled first.

Referees' Comments

In summary, the provision of any treatment for restoring an edentulous space requires appropriate case selection, treatment planning skills and technical ability. The two areas where there is agreement in the literature on the recommended standard of care using an implant retained prosthesis is the restoration of a missing anterior tooth space where the adjacent teeth are not restored and the use of 2 implants to provide an implant supported overdenture in the mandible.

Patient Selection Factors

Effects of smoking

Suggested Recommendation	Smoking as a single risk factor may not increase the risk of implant failure sufficiently to deny treatment.

Suggested Recommendation	Dental implants may be contraindicated in smokers who have other relevant risk factors present (eg requirement for maxillary bone grafts).

Comment	Implant survival may possibly be improved in smokers by implementing smoking cessation programmes or using preoperative antibiotics.

Diabetes Type 2

Suggested Recommendation	Dental implants are a suitable intervention for Type 2 Diabetics who are well controlled and do not have other relevant risk factors.

Parafunction including Bruxism

Suggested Recommendation	Caution should be exercised in accepting patients with suspected bruxism and other parafunctional activities.

Bone Grafting

Comment	Dental implants located after maxillary sinus augmentation have an increased failure rate that is likely to be of clinical significance.

Bone Quality and Volume

Comment	It would seem that a consensus opinion is required to set parameters for bone quality and quantity.

Osteoporosis and Menopausal Status

Suggested Recommendation	Postmenopausal status and mild osteoporosis are probably not clinically relevant risk factors for implant loss in most patients.

Hypothyroidism

Suggested Recommendation	Implants are not usually contraindicated in hypothyroid patients who are well-controlled on replacement therapy.

Cardiovascular Disease

Suggested Recommendation	Implants are not usually contraindicated in patients with cardiovascular disease where it is well controlled.

Irradiation of the jaw

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

Gene polymorphism (Interleukin and Calcitonin)

Comment	There seems insufficient evidence at this stage to make any recommendations as to the relevance of gene studies to patient selection for dental implants.

Infection, periodontitis, poor oral hygiene and uncontrolled caries

Comment	It is a consensus opinion that patients with infection, poor oral hygiene, uncontrolled caries and periodontitis should be excluded as candidates for dental implants.

General Health Status

Suggested Recommendation	Candidates for dental implants should have sufficiently good general health to undergo surgical and prosthodontic treatment[30].

Survival of teeth adjacent to an implant or an edentulous space

Comment	In bounded edentulous spaces there is an indication that teeth adjacent to a single tooth implant have a very low rate of complication.

Comment	There is some evidence to suggest that not providing a restoration for a bounded edentulous space does not significantly increase loss of adjacent teeth[53].

Failure rates in the maxilla compared to the mandible

Comment	The failure rate of implants in the completely edentulous maxilla may be higher than that of the mandible and this may be of clinical significance and a relevant patient selection factor.

Failure rates in partially edentulous jaws

Suggested Recommendation	Implants placed in partially edentulous arches usually have acceptable failure rates.

Force concentration and implant failure

Comment	For implants in the maxilla after bone grafting (sinus augmentation), efforts should be made to create a favourable occlusion in the mandible that disperses the occlusal force; An inability to do so may increase the risk of implant failure.

Anterior and posterior locations and implant failure

Comment	There is inadequate evidence to conclude that implant failure is greater at posterior locations compared to anterior.

Age and implant failure

Suggested Recommendation	Providing there was good life expectancy, age is not generally considered a risk factor for implant failure but implants should be delayed in young individuals until growth is complete.

Patient satisfaction

Conventional dentures v. mandibular implant retained dentures

Suggested Recommendation	Two - implant supported overdentures are a satisfactory treatment for edentulous patients with problems with their lower denture. In most patients it is recommended that a conventional denture be trialled first for one year[64, 65].

Suggested Recommendation	In patients with severely resorbed edentulous mandibles, implant supported prostheses may be the treatment of choice[64].

Patient satisfaction with conventional dentures after preprosthetic surgery v. dental implants

Comment	There is weak evidence that dental implants are preferable to preprosthetic surgery followed by conventional dentures, for patients with severely resorbed mandibles.

Patient satisfaction with implant retained dentures in the maxilla v. conventional dentures

Suggested Recommendation	In patients with sufficient bony support in the maxilla, conventional prostheses are usually the treatment of choice [67].

Patient satisfaction with various implant systems

Comment	Patient satisfaction is comparable with prostheses retained in the mandible on implants using either ball or bar-clip systems.

Comment	There is some evidence (one study) that in the maxilla long bar overdentures with a palatal covering have similar patient satisfaction ratings to systems without a palatal covering.

Comment	There is some evidence (one study) that patient satisfaction with 'implant retained removable overdentures on a long parallel bar' in the maxilla is higher than with a fixed prosthesis.

Comment	In patients with bounded edentulous spaces there is some evidence (one study) that patient satisfaction is similar for resin bonded fixed prostheses and implant supported prostheses.

Comparison of costs of implant and other systems

Comment	Conventional dentures in the mandible and 'resin bonded dentures in bounded edentulous spaces' are much cheaper than implant retained systems.

Conflicts of Interest – Nil

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Appendix A

Systematic Searches (examples)

Dental Implants
Patient satisfaction Cinahl
1. exp clinical trials/
2. Clinical trial.pt.
3. (clinic$ adj trial$1).tw.
4. ((singl$ or doubl$ or trebl$ or tripl$) adj (blind$3 or mask$3)).tw.
5. Randomi?ed control$ trial$.tw.
6. Random assignment/
7. Random$ allocat$.tw.
8. Placebo$.tw.
9. Placebos/
10. Quantitative studies/
11. Allocat$ random$.tw.
12. or/1-11
13. Meta analysis/
14. Meta analys$.tw.
15. Metaanaly$.tw.
16. exp Literature review/
17. (systematic adj (review or overview)).tw.
18. or/13-17
19. Commentary.pt.
20. Letter.pt.
21. Editorial.pt.
22. Animals/
23. or/19-22
24. 18 not 23
25. exp Dental Implants/
26. ((dental or tooth) adj implant$).mp.
27. 25 or 26
28. Patient Satisfaction/
29. Consumer Satisfaction/
30. ((patient$ or user$ or consumer$) adj satisfaction).mp.
31. or/28-30
32. 27 and 31 and (12 or 24)
33. (27 and 31) not 32
34. from 33 keep 4,7-8,10,13-14,16-17
35. 32 or 34
36. from 35 keep 1-16

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

Appendix B

Evidenced Based Healthcare Table Dental Implants

Reference: Feine JS, Carlsson GE, Awad MA, et al, 2002. **Reference No:** 1

Setting: Consensus symposium

Design Score: 4

Design Category: Expert opinion

Design Notes: Consensus statement

Intervention:

Mandibular 2-implant overdentures compared to conventional dentures

Participants:

Not specifically stated but main comparison studied was between patients receiving mandibular 2-implant overdentures and conventional dentures

	Control Group	Treatment Group	Follow up:
Age			
Number of patients			
Number of implants			

Inclusions:

RCTS, other studies and expert opinion

Exclusions:

Not stated

Selection notes:

How papers were selected was not further stated.

Outcome measures:

Overview of patient satisfaction and cost

Results:

The symposium concluded that there is overwhelming evidence that a 2-implant overdenture should become the first choice of treatment for the edentulous mandible. Regardless of attachment system used (bar, ball magnet) participants were more satisfied with the 2-implant overdentures compared to conventional dentures and found them more stable, easier to eat with and more comfortable for speaking.

Comments:

A consensus statement from a symposium. While it was stated that the results of RCTs was emphasised in drawing conclusions, it is not clear if a systematic literature search was made or the conference used a grading system assess the evidence. No references were given to the studies used.

Evidenced Based Healthcare Table Dental Implants

Reference: Coulthard P, Esposito M, Worthington HV, Jokstad A. 2003 **Reference No: 2**

Setting:

Design Score: 1-

Design Category: Meta analyses, systematic reviews of RCTs or RCTs with a high risk of bias

Design Notes: Cochrane review

Intervention:

Studies on patients receiving preprosthetic surgery to modify the oral anatomy and facilitate the retention of conventional dentures compared to osseointegrated implants to improve denture retention

Participants:

Edentulous patients who require either preprosthetic surgery and conventional dentures or construction of an implant retained denture.

	Control Group	Treatment Group	Follow up: 5 y
Age			
Number of patients	32	28	
Number of implants			

Inclusions:

Randomized controlled trials comparing preprosthetic surgery and implant retained dentures.

Exclusions:

No RCTs were excluded.

Selection notes:

Only one RCT was included.

Outcome measures:

Patient satisfaction, cost effectiveness and morbidity

Results:

Only one RCT was found that investigated 3 treatments in 90 patients. (One treatment group was irrelevant to the Cochrane Review). From the data on the remaining 60 patients, the authors concluded that there was weak evidence that patients are generally less satisfied with conventional dentures after preprosthetic surgery than with dentures retained by implants. There was not enough evidence to draw conclusions on the superiority of surgical techniques, types of implants or types of dentures.

Comments:

The paper appears to be a well conducted Cochrane Review.

Evidenced Based Healthcare Table Dental Implants

Reference: Butterworth CJ, Baxter AM, Shaw MJ, Bradnock G. 2001 **Reference No:** 3

Setting: Survey of United Kingdom clinical consultants

Design Score: 4

Design Category: Expert opinion

Design Notes: Opinion survey

Intervention:

Dental implantation (70% Branemark) Survey of risk factors

Participants:

Consultants in restorative dentistry within the United Kingdom NHS

	Control Group	Treatment Group	Follow up:
Age			
Number of patients			
Number of implants			

Inclusions:

Not applicable

Exclusions:

Not applicable

Selection notes:

75% of 145 consultants responded. 54/109 (50%) consultants were involved in the provision of implants

Outcome measures:

Opinion survey results, Contra-indications for patient selection

Results:

The majority of respondents thought that smoking(90%), psychoses(78%) and previous irradiation (70%) were important medical factors contraindicating implantation (Table2). Untreated periodontitis (95%), poor oral hygiene (80%) and uncontrolled caries (75%) were the most important oral contra-indications.

Contra-indications for implantation. Results of an United Kingdom survey (Data taken from graphs).

Contra-indication	Percent of respondents accepting factor as a contra-indication
Medical factors	
Smoking	90
Psychoses	78
Irradiation	75
Endocarditis	45
IDDM	35
Osteoporosis	25
Age	10
Oral factors	
Untreated periodontitis	95
Poor oral hygiene	80
Uncontrolled caries	75
Parafunction	55
Mucosal disease	50

Comments:

Evidenced Based Healthcare Table Dental Implants

Reference: Locker D. 1998 **Reference No:** 8

Setting:

Design Score: 1+

Design Category: Well conducted meta analyses, systematic reviews of RCTs, or RCTs with a low risk of bias

Design Notes: Systematic review

Intervention:

Patient satisfaction with dental implants compared with conventional dentures

Participants:

Patients with dental implants

	Control Group	Treatment Group	Follow up:
Age			
Number of patients			
Number of implants			

Inclusions:

Literature search 1980 to 1998, English language only, papers concerned with patient satisfaction with dental implants

Exclusions:

Excluded if papers did not report patient based assessments of treatment outcomes

Selection notes:

22 papers reporting 19 studies.

Outcome measures:

Review of patient reported outcomes

Results:

Locker found 22 papers describing 19 studies that included 3 RCTs, 2 cross sectional, 7 retrospective and 6 prospective case series studies, and 1 within subject crossover design. No meta-analyses were attempted.

One of the cross sectional studies showed that the only difference between implant and conventional denture patients was that the implant group had improved mechanical ability and fewer problems with chewing etc[82]. The other study[83] reported a psychological difference between implant and denture patients when severity of bone loss was taken into account.

The retrospective studies tended to show a largely positive response to implant therapy.

The prospective studies tended to show that implants resulted in a decline in the percentage of patients reporting problems and to record functional improvements. For example, patient satisfaction has been reported with conventional dentures compared to mandibular implant-supported prostheses (Cibirka et al, 1997)[84] in a pre, post, case series design. Satisfaction was measured with respect to comfort, function, speech, aesthetics, self-image, dental health. The installation of implant supported prostheses improved patient comfort, function, self-image, and dental health ($p<0.0001$).

The one within-subject crossover study[85] compared 2 mandibular prostheses (fixed and long-bar overdentures) in 15 edentulous subjects. Both types were judged as superior to conventional dentures previously worn.

An RCT[86] compared implant supported lower prosthesis and conventional dentures. At one year the implant group reported significantly fewer functional problems and were more able to chew hard foods. The second RCT[87] investigated 3 treatments in 90 patients: Implant supported overdentures in the mandible; Subjects treated surgically with vestibuloplasty and deepening of the floor of the mouth prior to construction of new dentures; And those receiving a set of new dentures. At

one year the two surgical groups had fewer complaints than those with conventional dentures, were better able to chew tough foods and were more satisfied overall. There were no differences in quality of life and in psychosocial factors between the groups. In the third RCT[88], fixed partial dentures supported on blade implants were compared with removable partial dentures in a trial of patients with Kennedy class 1 and 2 edentulous mandibles. It was concluded that implant supported prostheses were superior to the removable partial denture in terms of patient satisfaction and functioning but the magnitude of the difference was insufficient to favour use of implants in general in patients with this degree of tooth loss. The author concluded that the RCTs indicate that implants improve chewing ability and satisfaction with dentures but have not demonstrated effects with respect to quality of life.

Comments:

The author considered that the studies were difficult to summarise because of variations in design and in outcomes measured etc. It would appear though, that in the mandible, implants result in superior functional properties that result in improved patient satisfaction.

Evidenced Based Healthcare Table Dental Implants

Reference: Lambert PM, Morris HF, Ochi S 2000 **Reference No: 10**

Setting: 30 Dept of Veterans Affairs Clinics 2 University clinics. A DICRG study

Design Score: 2+

Design Category: 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

Design Notes: A cohort study

Intervention:

Dental implants. Effect of smoking on implant failure.

Participants:

Smokers and non smokers receiving dental implants

	Control Group	Treatment Group	Follow up: 90% > 3y
Age			
Number of patients			
Number of implants		2887	

Inclusions:

Able to benefit from participation and exhibit acceptable oral home care.

Exclusions:

An extensive list of exclusions were applied including medical conditions limiting life expectancy, IDDM, certain behaviour patterns and some dental conditions such as poor dental hygiene, bruxism, a history of necrotizing ulcerative gingivitis and any infections in the mouth. (see Implant Dent 1992;1:49-55).

Selection notes:

More than 2900 implants recorded but smoking history was recorded in 2887, 1928 non smokers and 959 smokers.

Outcome measures:

Survival of implants, study of confounding factors

Results:

Ninety percent of the patients had their implants for 3 years or more. A comparison of smokers with non smokers or smokers who had quit showed that implant failure rate was 8.9% in the smokers and 6% in the non smokers. Implants then are 1.5 times more likely to fail in smokers. The failure rate in smokers showed a variation with ethnicity and was greatest in Hispanics. When independence of the variables was assumed smoking was a highly significant variable detrimental to implant survival ($p=0.0037$). The risk of failure was greatest in the period when the implant was uncovered and before the prosthesis was placed. Implants in the maxillae were about 1.6 times more likely to fail in smokers than in the mandible. Hydroxyapaptite coated implants appeared to reduce the risk of implant failure in all patients but particularly in smokers. The use of pre-operative antibiotics reduced failures in both groups and appeared to eliminate the negative effect of smoking. Cessation of smoking appeared to also reduce risk.

There was no significant association of failure with age in all subjects.

Comments:

This data may not be relevant to the situation where the prosthesis is placed at time of implantation. No statistics are presented for some of the data. RR of implant failure for smokers/non-smokers was 1.5 (95% CI, 1.3 - 1.95).

Evidenced Based Healthcare Table Dental Implants

Reference: Eckert SE, Meraw SJ, Cal E, Ow RK 2000 **Reference No: 11**

Setting: Mayo Clinic Department

Design Score: 2-

Design Category: Case control or cohort studies with a high risk of confounding, bias or chance and a significant risk that the relationship is not causal.

Design Notes: A retrospective cohort-like study where outcomes in sub-groups were compared.

Intervention:

Dental Implants, Branemark or ITI systems. Factors associated with fractured implants

Participants:

Patients receiving implants either in completely edentulous arches or partially edentulous arches.

	Control Group	Treatment Group	Follow up: Up to 15 y
Age			
Number of patients			
Number of implants		4937	

Inclusions:

Not specifically stated

Exclusions:

Not stated

Selection notes:

From 1983 to 1998, 4937 implants were made, 1719 maxillary and 3218 mandibular. 3704 implants were used to support restorations in completely edentulous arches and 1233 in partially edentulous arches.

Outcome measures:

Comparison of fracture rates

Results:

Implants fracture at similar rates in the maxilla and the mandible (0.6%), but were more frequent in partially edentulous restorations (1.5%) than in restorations of completely edentulous arches (0.2%). All the implants that fractured were 3.75mm in diameter. No statistics given.

Comments:

Evidenced Based Healthcare Table Dental Implants

Reference: Esposito M, Hirsch JM, Lekholm U, Thomsen P. 1998. (2 papers) **Reference No: 12 & 45**

Setting: Review of data

Design Score: 2-

Design Category: Case control or cohort studies with a high risk of confounding, bias or chance and a significant risk that the relationship is not causal.

Design Notes: Systematic-like review of studies of varying design quality. The paper is not either a full systematic review though nor a meta-analysis.

Intervention:

Dental implants (Branemark only). Effect of biological factors on implant failure.

Participants:

Papers reporting biological failure rates in patients receiving Branemark implants

	Control Group	Treatment Group	Follow up:
Age			
Number of patients			
Number of implants		2812	

Inclusions:

Papers where Branemark implants were used and biological failures reported.

Exclusions:

Papers were excluded for the following reasons-
No detailed information on the distribution of implants between jaws,
No information on when the implant failed or if the follow up period was not stated. Patients with irradiated jaws were omitted from analysis on general survival of implants,
Prototype studies.

Selection notes:

159 papers identified up to 1997. 73 met the inclusion criteria.

Outcome measures:

Failure rate

Results:

Biologically related implant failure in a total of 2,812 implants was 7.7% over a 5-year period (bone graft cases excluded). In partially edentulous patients the failure rate was about half that of totally edentulous subjects (3.8%). The failure rate of implants in bone graft situations was much higher (14.9%). Failure in the maxilla was about 3 times that of the mandible except for the partially edentulous situation where there were similar rates of failure. No statistics were presented but data was aggregated to obtain means and percentages.

Their review also identified the following factors related to patient selection to be associated with biological failures; medical status of patient, smoking, bone quality, bone grafting, parafunctions and irradiation therapy. Except for irradiation therapy no synthesis of data was made to justify this comment. A simple meta-analysis of data was provided for the effect of irradiation therapy. Based on seven studies the failure rate in the maxilla was 29 of 99 implants (29.2%), and in the mandible 19 of 386 implants (4.9%) (Some of these patients had also received hyperbaric oxygen therapy). Based on 6 studies the effect of total irradiation dose was calculable. Doses less than 55Gy, resulted in a total failure rate of 2 implants in 75 (2.6%), and for greater than or equal to 55 Gy the rate was 35 in 347 (10.1%); All implants had been placed about 9 months or more after irradiation therapy.

Comments:

It appears that the paper is not a true systematic review as all papers regardless of design quality were included an no attempt was made to weigh the evidence by the quality of the design. It is seems likely that the patient groups were heterogeneous.

Evidenced Based Healthcare Table Dental Implants

Reference: Bain CA, Weng D, Meltzer A, Kohles SS, Stach RM. 2002 **Reference No: 13**

Setting: Patients were treated in private and university clinics.

Design Score: 2+

Design Category: 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

Design Notes: The paper has conducted a meta-analysis of a total of 9 prospective case series studies analysed by type of implant used. Because no RCTS were included it has been given a lower score than that of a meta-analysis of RCTs.

Intervention:

Patients receiving Osseotite implants (dual acid etched) or machine surfaced 3i implants. Implant survival in smokers v. non-smokers.

Participants:

Patients requiring single or multiple implants

	Control Group	Treatment Group	Follow up: 36 months
Age			
Number of patients			
Number of implants		4888	

Inclusions:

Edentulous patients in either the mandible or maxilla and requiring treatments that would include single tooth replacement, use of short span fixed bridges and full-arch restoration.

Exclusions:

Peridontal infection, uncontrolled diabetes, pregnancy, recent radiation to the head or neck, the need for concomitant bone augmentation or evidence of para-functional habits.

Selection notes:

For the Osseotite series, of the 2288 implants, data was available on 2274. Of the 397 implants in smokers 36 (9%) were lost to follow up. Of the non-smokers 112 (5.9%) of the 1877 implants were lost to follow up.
For the 2614 machine surfaced implants data was available on 2609 implants. Of the 492 smokers, 87 (17%) were lost to follow up. 219 of the 2117 (10.3%) implants in non-smokers were lost to follow up.

Outcome measures:

Implant cumulative survival rate at 36 months, smokers v. non-smokers

Results:

In the Osseotite group at a mean duration of 36 months from implantation, the cumulative survival rate in the smokers was 98.7% compared to 98.4% in the non-smokers. In the machine surfaced group at a meantime of 36 months post implant the cumulative survival rate in the smokers was 93.5% compared to 92.8% in the non smokers. The only difference thought to be of clinical significance was between the two implant types. The authors concluded that the Osseotite implant must be considered the implant of choice for patients who smoke.

Comments:

There was a marked patient selection bias in this series of patients particularly in the Osseotite group where the ratio of mandibular implants to maxillary was 0.99 in the smokers and 1.88 in the non-smokers. The comparative figures in those receiving machined surfaced implants was 1.51 and 1.31.

Evidenced Based Healthcare Table Dental Implants

Reference: Chuang SK, Wei LJ, Douglass CW, Dodson TB. 2002 **Reference No: 14**

Setting: Teaching hospital

Design Score: 2+

Design Category: 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

Design Notes: Retrospective cohort study on case series data..

Intervention:

Dental implant (Bicon) survival and factors related to this. Analysis allowed for clustering of failure and accounted for various time frames from implantation.

Participants:

All patients receiving implants at the clinic.

	Control Group	Treatment Group	Follow up: 23.8 m
Age		53.1 y	
Number of patients		677	
Number of implants		2349	

Inclusions:

All surgical treatment performed at the clinic; all patients including patients with chemotherapy.

Exclusions:

Inadequate records

Selection notes:

701 charts potentially on record, 24 not available for various reasons (eg death). 677 patients (96%) included.

Outcome measures:

Implant survival using sophisticated statistical techniques to allow for clustering of implant failure and varying time frames.

Results:

Overall one year and five year implant survival rates adjusted for clustered observations were 95.4% and 91.2%. Based on the adjusted multivariate model, factors associated with implant failure were current tobacco use (Hazard Ratio = 3.1, $p<0.01$), implant length (HR = 0.7 $p<0.01$), 2 stage implantation (HR = 0.3, $p<0.01$), well size (HR = 0.3, $p=0.01$) and immediate placement of implants (HR 1.8, P = 0.03). The authors' concluded that the factors that may be potentially modified to enhance survival are tobacco use, immediate placement of implants and staging.

Comments:

The study appears to be a careful and sophisticated analysis of data on a large number of patients to whom few exclusion criteria were applied.

Evidenced Based Healthcare Table Dental Implants

Reference: Bain CA. 1996 **Reference No: 15**

Setting: Private clinic

Design Score: 2-

Design Category: Case control or cohort studies with a high risk of confounding, bias or chance and a significant risk that the relationship is not causal.

Design Notes: Case control-like study of prospective case series data

Intervention:

Dental implantation in smokers and non smokers - effect of a smoking cessation protocol that required no smoking 1 week before implantation to 8 weeks after.

Participants:

Patients requiring dental implants, smokers and non smokers

	Control Group	Treatment Group
Age		
Number of patients		78
Number of implants		223

Follow up: Not stated

Inclusions:

Stage 2 surgery completed before October 1994.

Exclusions:

Not stated

Selection notes:

78 consecutive patients

Outcome measures:

Implant failure, smoking status, observing a smoking cessation protocol

Results:

Patients were classified into one of three groups; non smokers (NS), those who smoked through the period 1 week before till 8 weeks after initial placement(S) and those who observed a cessation protocol over this period(CS). Failure rates in the 3 groups NS, CS and S were respectively 5.68%, 11.76% and 38.46%. The difference in outcome between the NS and S groups was significant ($p<0.005$) as was the difference between the CS and S groups ($P<0.05$). There was no significant difference between the NS and CS groups. Bain concluded that a smoking cessation protocol showed promise in improving implant outcome in smokers.

Comments:

Evidenced Based Healthcare Table Dental Implants

Reference: Wilson TG, Jr., Nunn M 1999 **Reference No: 16**

Setting: Private practice

Design Score: 2-

Design Category: Case control or cohort studies with a high risk of confounding, bias or chance and a significant risk that the relationship is not causal.

Design Notes: A case control study based on case series data. Controls (implant successes) were either randomly selected from the database or matched depending on subset analysis.

Intervention:

Relation of interleukin -1 genotype to implant (Branemark and Straumann) failure. The kit used to identify genotype status is referenced but not described.

Participants:

Patients with failed or successful implants on clinic records,

	Control Group	Treatment Group
Age		
Number of patients	38	27
Number of implants	68	33

Follow up: Not stated

Inclusions:

Implant failures selected from case series data,

Exclusions:

Not stated

Selection notes:

Data on 913 implants were available of which 36 were failures: 3 failures were excluded because they fractured without bone loss occurring. This gave 33 implant failures in 27 patients. Controls (implant successes) were randomly selected from the data base - 68 implants in 38 patients. A further subset of 20 successes were selected from the sample pool to match a subset of 20 of the failures that were independent.

Outcome measures:

Interleukin-1 genotype, distribution among selected groups. For the analysis the patients were divided into subsets:
Subset 1, 33 failed implants compared to 68 successful implants randomly chosen from the database
Subset 2 independence was assumed, 20 patients with 20 failed implants compared to 20 matched successes
Subset 3, compared 23 of the 33 implants that were lost due to non-mechanical reasons with the same control group as in subset 1.

Results:

Statistical testing showed no difference in the distribution of genotypes between the groups. There was no evidence that IL-1 genotype is linked to implant failure. Smoking increased risk of implant loss compared to non smokers (RR = 2.5, (95% CI, 1.13-5.55), P = 0.024).

Comments:

Three analyses of the available data were made.

Evidenced Based Healthcare Table Dental Implants

Reference: Ekfeldt A, Christiansson U, Eriksson T, et al 2001 **Reference No: 17**

Setting: 6 prosthodontic clinics

Design Score: 2-

Design Category: Case control or cohort studies with a high risk of confounding, bias or chance and a significant risk that the relationship is not causal.

Design Notes: A case control study in which patients who had lost greater than half their implants were compared with a matched group who had lost no implants.

Intervention:

A fixed prosthesis or an overdenture supported by at least 4 implants (Branemark System) in the maxilla. Factors associated with multiple implant failure.

Participants:

Patients who dental implants placed in the maxilla.

	Control Group	Treatment Group
Age		
Number of patients	27	27
Number of implants	150	151

Follow up: Failure before and after 1 year

Inclusions:

Completely edentulous maxilla and subsequently lost at least half of the implants.
A matched control group who had lost no implants. Matching criteria were, amount of implants placed in same timeframe, gender and age

Exclusions:

Note stated

Selection notes:

Outcome measures:

Narrative description of likely risk factors

Results:

Factors thought likely to contribute to failure were bruxism, smoking and lack of bone support. No statistics were

Comments:

Evidenced Based Healthcare Table Dental Implants

Reference: Elsubeihi ES, Zarb GA. 2002 **Reference No: 18a**

Setting: University to Toronto clinic database

Design Score: 2-

Design Category: Case control or cohort studies with a high risk of confounding, bias or chance and a significant risk that the relationship is not causal.

Design Notes: A cohort study

Intervention:

Dental implants, effect of diabetes on implant failure.

Participants:

Diabetics receiving implants

	Control Group	Treatment Group	Follow up: 1 to 17 years
Age			
Number of patients	30	15	
Number of implants	111	59	

Inclusions:

15 diabetic patients selected from database. 30 controls matched for age, gender and implant location

Exclusions:

Not stated

Selection notes:

From 464 consecutive patients, 15 diabetics selected.

Outcome measures:

Failure rate

Results:

Implant failure was similar between the groups (diabetics 7%, controls 6%) and crestal bone loss was not greater in the longer term. They concluded that controlled diabetics were not at increased risk of implant failure.

Comments:

Classification of diabetes was not recorded nor was the degree of diabetic control. RR for failure in diabetics cf to failure in nondiabetics was 1.08 (95% CI 0.33-3.52)

Evidenced Based Healthcare Table Dental Implants

Reference: Elsubeihi and Zarb 2002 **Reference No: 18b**

Setting: University to Toronto clinic database

Design Score: 2-

Design Category: Case control or cohort studies with a high risk of confounding, bias or chance and a significant risk that the relationship is not causal.

Design Notes: A cohort study

Intervention:

Dental implants, effect of smoking on implant failure.

Participants:

Smokers and non-smokers receiving implants

	Control Group	Treatment Group	Follow up: 1 to 20 years
Age			
Number of patients		389	
Number of implants		1539	

Inclusions:

Smokers defined as smoking at the time of implant and non-smokers on a database

Exclusions:

Not stated

Selection notes:

104 smokers and 285 non-smokers (389 in total) on a database containing data on 464 consecutive patients

Outcome measures:

Implant failure

Results:

The relative risk (RR) of failure in those who smoked during the initial healing phase was 1.69 times that of those who did not smoke. In patients with a smoking history of 25 years of more the risk of late implant failure was 1.91 that of those who did not smoke. The differences between groups was not significant for early implant failure. Those with a positive smoking history had a significant prevalence of late implant failure.

Comments:

Evidenced Based Healthcare Table Dental Implants

Reference: Minsk L, Polson AM, Weisgold A, et al. 1996 **Reference No: 19**

Setting: University Dental Clinic

Design Score: 2+

Design Category: 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

Design Notes: Cohort like study of retrospective data.

Intervention:

Dental implants, 70% Branemark, factors effecting implant failure.

Participants:

	Control Group	Treatment Group
Age		
Number of patients		380
Number of implants		1263

Follow up: Up to 6 years

Inclusions:

Not specifically stated

Exclusions:

Not specifically stated

Selection notes:

1263 implants placed of which 480 (38%) were lost to follow up over the entire period..

Outcome measures:

Survival rate and descriptive analysis of failures

Results:

The cumulative survival rate was 91.3%. Fourteen percent of the implants failed in the maxilla compared 4.4% in the mandible. Failure rate did not appear to be effected by smoking status or gender in this study.

Comments:

RR for failure in the maxilla compared to the mandible was 3.21 (95% CI 1.87-5.51)
RR for failure in smokers compared to non smokers was 1.19 (95% CI 0.71-1.99).

Evidenced Based Healthcare Table Dental Implants

Reference: Haas R, Haimbock W, Mailath G, Watzek G 1996 **Reference No: 20**

Setting: University clinic

Design Score: 2+

Design Category: 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

Design Notes: Case control analysis of case series data. Smokers and non smokers appear to have been modestly well matched despite the absence of selection criteria.

Intervention:

Measures of peri-implantitis in smokers and non smokers with dental implants (Branemark and IMZ).

Participants:

Smokers and non smokers with dental implants

	Control Group	Treatment Group
Age	52.7	53.6
Number of patients	314	107
Number of implants	1000	366

Follow up: Smokers, 22.4 m, non smokers 21.9 m.

Inclusions:

Regular recall data available, smoking status known and masticatory functional loading of the implant for at least one year.

Exclusions:

Not stated

Selection notes:

Selected from case series data, 366 implants (108 maxillary, 258 mandibular) in 107 patients who smoked and 1000 (234 maxillary, 766 mandibular) implants in 314 nonsmokers.

Outcome measures:

Hygiene, bleeding index, rate of peri-implant mucosal inflammation, mean peri-implant pocket depth and radiographically determined bone resorption.

Results:

In the maxilla, bleeding index, degree of peri-implant mucosal inflammation, mean peri-implant pocket depth and radiographically determined bone resorption were significantly worse in the smokers ($p<0.01$). There were no significant differences observed in the mandible. The authors concluded that smokers have a greater risk of developing peri-implantitis.

Comments:

Evidenced Based Healthcare Table Dental Implants

Reference: Kan JYK, Rungcharassaeng K, Lozada JL, Goodacre CJ. 1999 **Reference No: 21**

Setting: University clinic

Design Score: 2-

Design Category: Case control or cohort studies with a high risk of confounding, bias or chance and a significant risk that the relationship is not causal.

Design Notes: Retrospective case control like analysis of case series data.

Intervention:

Implant survival in grafted maxillary sinuses. Effect of smoking.

Participants:

Patients with implants in grafted maxillary sinuses; smokers and non smokers.

	Control Group	Treatment Group	Follow up: 41.6 m
Age		64.6 y (all subjects)	
Number of patients	44	16	
Number of implants	158	70	

Inclusions:

Completed surgical and prosthodontic treatment for prostheses placed on implants in grafted maxillary sinuses.

Exclusions:

Not stated

Selection notes:

A total of 118 patients treated, 60 (51%) of whom were available for follow up.

Outcome measures:

Survival analysis in smokers and non smokers

Results:

Cumulative success rates were significantly different between smokers (65.3%) and non smokers (82.7%) (p= 0.027). There was no correlation though between implant failure and amount of cigarette consumption. The authors concluded that smoking appears to be detrimental to the success of osseointegrated implants in grafted maxillary sinus regardless of cigarette consumption.

Comments:

There were only a small number of smokers for analysis, a large number who were not available for analysis and no comparison of baseline characteristics between smokers and no smokers.

Evidenced Based Healthcare Table Dental Implants

Reference: Fartash B, Tangerud T, Silness J, Arvidson K 1996 **Reference No: 22**

Setting: 2 Swedish dental faculties

Design Score: 3

Design Category: Non-analytic studies

Design Notes: Prospective case series

Intervention:

Single crystal sapphire implants (Bioceram) and overdentures in the mandible; factors influencing implant survival.

Participants:

Patients with serious functional problems associated with mandibular full dentures supported on Bioceram sapphire implants.

	Control Group	Treatment Group
Age		63.5y
Number of patients		86
Number of implants		324

Follow up: At least 3y

Inclusions:

Patients with serious functional problems associated with mandibular full dentures, with general instability during normal functional activity and associated negative effects on social life.

Exclusions:

History of immune disease, uncontrolled diabetes or substance abuse.

Selection notes:

No dropouts reported

Outcome measures:

Implant success rate, Observation of reasons for failure

Results:

The cumulative success rate at 5 years was 91.3%. The author's concluded that the main risk factor for implant loss was an association between bone quality and anatomy, with heavy smoking being a risk factor The association was not statistically verified.

Comments:

Evidenced Based Healthcare Table Dental Implants

Reference: Olson JW, Shernoff AF, Tarlow JL, Colwell JA, Scheetz JP, Bingham SF 2000 **Reference No: 23**

Setting: 13 University and Veterans' clinics

Design Score: 3

Design Category: Non-analytic studies

Design Notes: A prospective case series study

Intervention:

Dental implant survival in type 2 diabetic males. Associated risk factors. A variety of implants were used. A conventional maxillary denture and a mandibular implant supported Hader bar clip-retained overdenture was fitted in each patient.

Participants:

Edentulous Type 2 diabetics.

	Control Group	Treatment Group	Follow up: 46.9 m
Age		62.7	
Number of patients		89	
Number of implants		178	

Inclusions:

Veterans with Type 2 diabetes

Exclusions:

Not further stated

Selection notes:

Females were not specifically excluded but their absence reflected the veteran population. 58/89 (65%) completed the 5 year schedule. 31 were terminated prematurely, 23 due to death.

Outcome measures:

Implant survival and factors effecting survival.

Results:

Nine percent of the 178 implants failed. Duration of diabetes ($p<0.025$) and implant length ($p<0.001$) were the only variables related to implant failure. Smoking, HbA1c, fasting plasma glucose and baseline diabetic therapy were not significantly related to failure. The authors' concluded that type 2 diabetes is not a contraindication for implantation.

Comments:

Evidenced Based Healthcare Table Dental Implants

Reference: Bragger U, Aeschlimann S, Burgin W, Hammerle CH, Lang NP. 2001 **Reference No: 24**

Setting: University and private clinics

Design Score: 3

Design Category: Non-analytic studies

Design Notes: Case series study

Intervention:

Fixed partial dentures on teeth and implants (ITI system). Biological and technical complications.

Participants:

Patients receiving fixed partial dentures

	Control Group	Treatment Group	Follow up: 4-5 y
Age		55.7 y	
Number of patients		85	
Number of implants		105	

Inclusions:

Not specifically stated

Exclusions:

Not stated

Selection notes:

Of the 85 patients recruited to the study it appears that the first 45 to reach their 5 year examination were included in their analysis.

Outcome measures:

Implant survival, complication rate in relation to technical and biological failures.

Results:

Of the bridge abutments 144 were teeth and 105 implants. These supported a total of 116 fixed partial dentures. Technical complications were significantly associated with bruxism ($p<.01$). Biological complications were not significantly associated with either smoking or impaired general health.

Comments:

The RR for a technical complication in bruxers compared to non bruxers was 3.46 (95% CI 1.71 - 7.02).

Evidenced Based Healthcare Table Dental Implants

Reference: Eckert SE, Meraw SJ, Weaver AL, Lohse CM. 2001 **Reference No: 25**

Setting: A Mayo Dental Clinic

Design Score: 3

Design Category: Non-analytic studies

Design Notes: Case series

Intervention:

Branemark, Wide-Platform Mk2 implants. Failure rate in partially edentulous arches..

Participants:

Partially edentulous patients

	Control Group	Treatment Group
Age		52.2
Number of patients		55
Number of implants		77

Follow up: 297 days

Inclusions:

Patients in partially edentulous arches.

Exclusions:

Not stated

Selection notes:

85 implants were initially placed. For the risk factor part of the study, 7 patients declined to make a medical record available. This left 55 patients in the study with 77 implants.

Outcome measures:

Implant failure and analysis of risk factors

Results:

In 55 patients the implant success rate was only 74%, at an average follow up of 297 days. Failure was due to osseointegration not being achieved or maintained. Tobacco use, sinus grafting, bruxism, and previous root canal therapy had no statistically significant effect on outcome.

Comments:

Evidenced Based Healthcare Table Dental Implants

Reference: Keller EE, Tolman DE, Eckert SE 1999 **Reference No: 26**

Setting: Mayo Clinic

Design Score: 3

Design Category: Non-analytic studies

Design Notes: Retrospective study over a 12 year period.

Intervention:

Dental implant survival after maxillary antral-nasal autogenous bone graft reconstruction of compromised maxilla. Risk factors influencing survival.

Participants:

Patients requiring bone graft reconstruction of compromised maxilla prior to dental implantation

	Control Group	Treatment Group	Follow up: Up to 12 y
Age		48	
Number of patients		54	
Number of implants		248	

Inclusions:

Search of database for patients receiving dental implants (Branemark) following bone graft reconstruction of compromised maxilla.

Exclusions:

Not stated

Selection notes:

54 consecutive patients, 1 dropout due to death.

Outcome measures:

Review of factors contributing to implant failure

Results:

Patient selection risk factors for failure were current use of nicotine, history of sinusitis and molar site. 13.3 % of implants were removed. No statistics were presented.

Comments:

Evidenced Based Healthcare Table Dental Implants

Reference: Feloutzis A, Lang NP, Tonetti MS, et al. 2003 **Reference No: 27**

Setting: University clinic

Design Score: 3

Design Category: Non-analytic studies

Design Notes: Retrospective case series

Intervention:

Dental implantation (ITI system); effects of smoking and IL-1 gene status in patients with chronic periodontitis.

Participants:

90 patients with ITI implants and chronic periodontitis (39 (43%) non smokers, 23 (26%) former smokers, 14 (16%) moderate smokers and 14 (16%) heavy smokers).

	Control Group	Treatment Group	Follow up: 5.6 y
Age		59.5 y	
Number of patients		90	
Number of implants		182	

Inclusions:

Carrying one or more ITI implant, availability of a standardised periapical radiograph at the time of prosthetic loading or within 6 months and at least 20 years of age and in good general health.

Exclusions:

Diabetes, HIV infection, immuno suppressive therapy or compromised immune function.

Selection notes:

Consecutive series

Outcome measures:

Smoking, IL-1 status, radiographic determination of peri-implant bone loss, full mouth bleeding on probing.

Results:

At a mean time of 5.6 years post implantation in a cohort of 90 patients they found that absolute bone loss was significantly greater in current heavy smokers compared to non smokers ($p<0.02$) and between current heavy smokers and former smokers ($P<0.004$). Upon stratification by smoking status, the data showed that in those who were IL-positive bone loss was significantly greater in heavy smokers compared to non smokers ($p<0.01$) but no difference was seen in those who were IL-1 negative. The authors concluded that heavy smokers who are positive for the IL-1 gene complex polymorphism have an increased risk of peri-implant bone loss.

Comments:

Evidenced Based Healthcare Table Dental Implants

Reference: Nosaka Y, Tachi Y, Shimpuku H, Kawamura T, Ohura K 2002 **Reference No: 28**

Setting: Japanese private clinic

Design Score: 3

Design Category: Non-analytic studies

Design Notes: Prospective case series

Intervention:

Dental implantation (Astra Tech AB, Molndal Sweden). Calcitonin receptor gene polymorphism - effect on marginal bone loss after implantation but before adding of the prosthesis.

Participants:

Edentulous patients

	Control Group	Treatment Group
Age		54.8
Number of patients		35
Number of implants		237

Follow up: Av 4.1months for mandibles, 6.1 for maxilla

Inclusions:

Healthy subjects undergoing treatment for edentulousness

Exclusions:

Not stated

Selection notes:

35 subjects

Outcome measures:

Marginal bone loss around implants. Effect of calcitonin receptor gene polymorphism.

Results:

Those with the TC gene type were 20 times more likely to suffer buccal marginal bone loss in the mandible than those with the CC genotype during the first phase of treatment - placement of implantation but before connection of the abutments (p=.004, RR 20.0 (95% CI 2.62-152.64). The effect was not observed in the maxillae. There was no significant difference in the distribution of age, smoking status and postmenopausal status between patients with and without bone loss.

Comments:

Evidenced Based Healthcare Table Dental Implants

Reference: Heinikainen M, Vehkalahti M, Murtomaa H. 2002 **Reference No: 29**

Setting: Survey of current practice in Finland

Design Score: 4

Design Category: Expert opinion

Design Notes: Survey

Intervention:

Dental implants, opinion survey of risk factors

Participants:

Finnish practitioners and teachers

	Control Group	Treatment Group	Follow up:
Age			
Number of patients			
Number of implants			

Inclusions:

Random selection of dentists selected from members of the Finnish Dental Association and a group of dental teachers.

Exclusions:

Dental teachers in the fields of surgery and orthodontics

Selection notes:

400 dentists randomly selected from a register, and 47 fulltime dental teachers. 77% of the practitioners responded and 74% of the teachers

Outcome measures:

Results of a survey

Results:

Less than 50% of the dentists were prepared to recommend implants where oral hygiene was deficient, untreated caries was present, the patient had several deep peridontal pockets, or when the patient had poorly controlled diabetes mellitus or was a heavy smoker. Rheumatoid arthritis, past myocardial infarction or age where not generally considered important factors to decline implantation.

Percentage of Finnish Dentists recommending implant therapy in 10 different cases			
Case	Public sector dentists (n=164) %	Private sector dentists (n=145) %	Dental teachers (n=34) %
Oral factors			
Despite clear oral hygiene instructions and attempts the patient had not adopted sufficient oral hygiene ability	10	19	21
The patient had several untreated caries lesions in molars and premolars	26	46	32
The patient had several deep (>6mm) periodontal pockets in molars and premolars	16	27	9
Medical factors			
The patient has diabetes mellitus and receives insulin treatment. Despite several daily injections the level of blood glucose varies	10	15	15

Percentage of Finnish Dentists recommending implant therapy in 10 different cases			
widely.			
The patient had a myocardial infarction 1 year ago	73	85	94
The patient had surgery for an endoprosthesis in his/her right knee 2 years ago because of rheumatoid arthritis	69	78	77
Personal factors			
The patient is over 70 years of age and in good health	78	88	94
The patient smokes about 20 cigarettes daily	44	47	15
The patient is outside the recall system	73	76	73
The patient's request was an aesthetic outcome	95	97	94

Comments:

The paper appears to be a well conducted review of current patient selection practice in Finland in 2000.

Evidenced Based Healthcare Table Dental Implants

Reference: Anonymous, Faculty of Dentistry, The Royal College of Surgeons. England, 1997. **Reference No: 30**

Setting: Royal College of Surgeons

Design Score: 4

Design Category: Expert opinion

Design Notes: Expert opinion

Intervention:

Dental implants. Patient selection factors. Consensus guideline.

Participants:

Members of Faculty

	Control Group	Treatment Group	Follow up:
Age			
Number of patients			
Number of implants			

Inclusions:

Not specified

Exclusions:

Not specified

Selection notes:

Outcome measures:

Guideline

Results:

General medical factors described were -
Providing there was good life expectancy there was no upper age limit,
General health should be good enough to undergo surgical and prosthodontic treatment,
Subjects with diabetes mellitus should be well controlled,
Tobacco smokers should be counselled to quit or reduce smoking or be refused treatment especially if other risk factors are present,
Severe psychoses/neuroses is usually a contra-indication,
Other contra-indications include immunodeficiency, bleeding disorders, drug/substance abuse, bone disorders and possibly infective endocarditis.
General oral/dental factors were-
The patient should have healthy mucous membranes,
Dentate subjects should have healthy periodontal tissues and sound teeth,
Poor oral hygiene, untreated periodontal disease and uncontrolled caries are contra-indications,
Caution should be exercised in accepting patients with suspected bruxism and other parafunctional activities,
There should be adequate bone quality and volume.

Comments:

Evidenced Based Healthcare Table Dental Implants

Reference: Morris HF, Ochi S, Winkler S 2000 **Reference No: 32**

Setting: 30 Dept of Veterans Affairs Clinics 2 University clinics. A DICRG study

Design Score: 2+

Design Category: 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

Design Notes: A cohort study

Intervention:

Dental implants, effect of diabetes on failure rates

Participants:

Diabetics and non-diabetics receiving dental implants

	Control Group	Treatment Group	Follow up: 3 y
Age			
Number of patients			
Number of implants		2887	

Inclusions:

Able to benefit from participation and exhibit acceptable oral home care.

Exclusions:

Patients with Type 1 diabetes were specifically excluded. An extensive list of other exclusions were applied including medical conditions limiting life expectancy, certain behaviour patterns and some dental conditions such as poor dental hygeine, bruxism, a history of necrotizing ulcerative gingivitis and any infections in the mouth. (see Implant Dent 1992;1:49-55).

Selection notes:

A total of 2887 implants were placed in 663 patients; 2632 implants in non-diabetics and 255 (8.8%) in Type 2 diabetics.

Outcome measures:

Implant survival as effected by various risk factors

Results:

Assuming Type 2 Diabetes as an independent variable, implant failure was significantly worse in the diabetics (p=0.02). This significance was reduced when covariation was considered (p=0.046). The use of hydroxyapatite coated implants improved outcomes in the diabetics by 13.2%. The use of chlorhexidine rinses following implant placement and preoperative antibiotics also improved outcomes for the diabetics (no statistics reported). Bone density did not appear to be a major influence on implant survival in diabetics. In all patients health status (p=0.0145) and bone quality (p=0.0104) were highly significant correlates of implant success. In non diabetics the failure rates for patients with bone quality 1, 2, 3, and 4 were respectively 5.0%, 6.2%, 8.0% and 6.8%; In diabetics, 10.7%, 5.3%, 6.6%, 22.7%.

Comments:

The RR of failure in diabetics compared to non-diabetics was 1.15 (95% CI 0.74 - 1.79). No statistics were reported to support some of the conclusions reached.

Evidenced Based Healthcare Table Dental Implants

Reference: Fiorellini JP, Chen PK, Nevins M, Nevins ML. 2000 **Reference No:** 33

Setting: A university and a private clinic

Design Score: 3

Design Category: Non-analytic studies

Design Notes: Retrospective case series

Intervention:

Factors influencing implant (Branemark, ITI) survival in diabetic patients.

Participants:

Diabetic patients with implants, Type 1 (6 patients) Type 2 (34).

	Control Group	Treatment Group	Follow up: 4.1 y
Age		48.7	
Number of patients		40	
Number of implants		215	

Inclusions:

Diabetic patients with implants. Patients on clinic records

Exclusions:

Not stated

Selection notes:

Not stated

Outcome measures:

Survival analysis and factors influencing this.

Results:

The overall success rate was 85.6% at a mean follow up of 4.1 years. Seventy-seven percent of the failures occurred in the first year. Success rates for the maxilla and mandible were 85.5% and 85.7% and for anterior and posterior regions of the jaw 83.5% and 85.6% (Significance not stated). The authors' concluded that though implant survival was lower in diabetics than in the general population there was still a reasonable success rate.

Comments:

Evidenced Based Healthcare Table Dental Implants

Reference: Wannfors K, Johansson B, Hallman M, Standkvist T. 2000 **Reference No: 34**

Setting: Hospital clinic

Design Score: 1-

Design Category: Meta analyses, systematic reviews of RCTs or RCTs with a high risk of bias

Design Notes: RCT. Patients randomised to one of 2 groups. Design neither included concealment or blinding, but patients in the 2 groups appear to be well matched.

Intervention:

Sinus grafting by a one or two stage technique. Factors related to implant failure.

Participants:

Edentulous patients requiring sinus grafting before implantation (Branemark).

	Control Group	Treatment Group	Follow up: I y
Age	Median 57	Median 54	
Number of patients	20	20	
Number of implants	74	76	

Inclusions:

More than 2 mm but less than 7mm of residual bone under the maxillary sinuses, age less than 80 y, no clinical or radiological diagnosis of pathology in the maxillary sinuses, no bone disease or medication known to effect bone metabolism.

Exclusions:

Not further stated

Selection notes:

No dropouts.

Outcome measures:

Implant survival and factors related to this.

Results:

Of the implants in grafted regions done by a one stage system, 79% survived at one year. The failure rate was 8.9 times that of implants in non grafted regions (95% CI, 2.9 - 28). For the 2 stage system the failure rate was 89% . The failure rate was 4.1 times that of non grafted implants (95% CI 1.2 - 14). In relation to patient selection factors, bruxism ($p<0.05$) and post operative infections ($P<0.07$) were related to implant failure. Significance was dependent on statistical test applied.

Comments:

The main objective of the paper was the comparison of 2 surgical techniques. The results of this are not included here.

Evidenced Based Healthcare Table Dental Implants

Reference: Glauser R, Ree A, Lundgren A, Gottlow J, Hammerle CH, Scharer P, 2001. **Reference No: 35**

Setting: University clinic

Design Score: 3

Design Category: Non-analytic studies

Design Notes: Case series data

Intervention:

Immediate loading of implants (Branemark) in a one stage procedure after tooth extracted. Prostheses placed immediately or within 11 days. Guided bone regeneration when required. Implant survival and associated risk factors

Participants:

Patients requiring implants

	Control Group	Treatment Group	Follow up: 1y
Age		52	
Number of patients		41	
Number of implants		127	

Inclusions:

Adequate bone height, healthy appearance of sinuses (when installing implants in the posterior part of the maxilla), implant site free from acute infection or extraction remnants, sufficient primary implant stability.

Exclusions:

Risk of affecting patient's health, co-operation questionable, no informed consent, planned implant area previously subject to lesions or showing signs of bone disease, previous bone augmentation at implant site.

Selection notes:

Case series.

Outcome measures:

Implant survival rate and analysis of factors related to failure.

Results:

The cumulative success rate was 82.7% at one year, 91% for regions other than the posterior maxilla and 66% for implants placed in the posterior maxilla. Implants in bruxers (41%) were lost more frequently than in non-bruxers (12%). None of these differences were statistically significant when analysed at patient level..

Comments:

Evidenced Based Healthcare Table Dental Implants

Reference: Chanavaz M. 1996 **Reference No: 36**

Setting: University/hospital clinic

Design Score: 3

Design Category: Non-analytic studies

Design Notes: A retrospective case series

Intervention:

Sinus grafting prior to implantation. Factors relating to patient selection. A variety of methods and materials were used over a period of 15 years.

Participants:

Patients requiring sinus grafting prior to implantation

	Control Group	Treatment Group	Follow up: Up to 15 y
Age			
Number of patients		402	
Number of implants			

Inclusions:

Not stated

Exclusions:

Not stated

Selection notes:

No details recorded

Outcome measures:

Success rates and factors relating to success.

Results:

Outcomes up to 15 years were reported during which time a variety of techniques and materials were used. Long-term success was obtained in 396/402 cases (98.5%). The 6 total failures were all found in the 120 post menopausal women (5%). Five of these 6 women were in poor health. Males presented the most favourable immediate successes (148/154, 96%), followed by women with normal menstrual cycles (95/101, 94%). The post menopausal group had the least favourable immediate success (120/147, 82%).

Comments:

Confounding may have been introduced with changes in methods and materials.

Evidenced Based Healthcare Table Dental Implants

Reference: Becker W, Hujoel PP, Becker BE, Willingham H, 2000 **Reference No: 37**

Setting: Private clinic

Design Score: 2-

Design Category: Case control or cohort studies with a high risk of confounding, bias or chance and a significant risk that the relationship is not causal.

Design Notes: Non randomised case control study. Control group was selected so that a gender balance was

Intervention:

Effect of osteoporosis and bone quality on implant (Branemark) failure.

Participants:

Patients receiving implants

	Control Group	Treatment Group
Age	64.9	65.8
Number of patients	49	49
Number of implants	180	184

Follow up: Treatment, 46 m; Control, 45 m.

Inclusions:

Individuals in practice who experienced implant failure between 1986 and 1998. Controls were those seen between September and December 1998 enrolled in an annual implant evaluation programme.

Exclusions:

Not stated

Selection notes:

49 patients (30 females) selected from case series data who had lost implants. Controls consisted of 51 patients (30 females) of whom 49 agreed to take part.

Outcome measures:

Osteoporosis as assessed by dexa scanning of the ulna and radius, subjective assessment of bone quality. Association with implant loss.

Results:

It was reported that osteoporosis as assessed by dexa scanning of the ulna and radius was not significantly related to implant loss. Simple visual assessment of local bone quality was related to implant failure; Implants placed in thin cortical bone slightly increased the risk of loss by 130% compared to implants in a thick cortical layer or compact bone (RR 2.3, 95% CI, 1.0- 5.4).

Comments:

Case and controls were well matched for most criteria. Method of matching controls was not described.

Evidenced Based Healthcare Table Dental Implants

Reference: Orenstein IH, Tarnow DP, Morris HF, Ochi S 1998 **Reference No: 38**

Setting: 30 Dept of Veterans Affairs Clinics 2 University clinics. A DICRG study

Design Score: 2-

Design Category: Case control or cohort studies with a high risk of confounding, bias or chance and a significant risk that the relationship is not causal.

Design Notes: A cohort study.

Intervention:

Mobility of the implant at time of placement. Factors related to this

Participants:

Veterans requiring implants.

	Control Group	Treatment Group	Follow up: From placement to uncovering
Age		Range 20 to 80 y	
Number of patients			
Number of implants		2641	

Inclusions:

Mostly male veterans

Exclusions:

An extensive list of exclusions were applied including medical conditions limiting life expectancy, IDDM, certain behaviour patterns and some dental conditions such as poor dental hygiene, bruxism, a history of necrotizing ulcerative gingivitis and any infections in the mouth. (see Implant Dent 1992;1:49-55).

Selection notes:

Patients were selected into groups on the basis of data in records

Outcome measures:

Implant mobility at placement and factors related to this

Results:

Patient selection variables associated with mobility at placement were age (p=.05) with the lowest percentage of mobile implants occurring in the young; anterior-posterior jaw location, with posterior locations slightly more likely to be mobile (p=0.032); and bone density where mobility was more likely in patients with bone quality-4 compared to those with bone quality in grades Q1 to Q3 (p=0.009).

Comments:

The relevance of this data to patient selection seems academic since of the eighty-one implants mobile at placement 76 had integrated at uncovering.

Evidenced Based Healthcare Table Dental Implants

Reference: von Wowern N, Gotfredsen K. 2001 **Reference No: 41**

Setting: University clinic

Design Score: 2-

Design Category: Case control or cohort studies with a high risk of confounding, bias or chance and a significant risk that the relationship is not causal.

Design Notes: Patients were randomised into 2 treatment groups of 11 patients each. However much of the analysis relies on a comparison of data pre and post placement of the prosthesis when the data from the 2 groups is aggregated. For this reason the design was basically that of a cohort-like study followed over time.

Intervention:

Bone mineral content of the mandible at prosthesis placement and, 2 and 5 years later. Prosthesis was supported on Astra implants held by either a bar or ball system. The effect of osteoporosis pre-treatment on bone mineral loss in the mandible was also investigated.

Participants:

Edentulous healthy patients

	Control Group	Treatment Group	Follow up: 2 and 5 y
Age		54 - 78 y	
Number of patients		22	
Number of implants		44	

Inclusions:

Healthy persons referred for treatment

Exclusions:

Not stated

Selection notes:

There appear to have been no dropouts

Outcome measures:

Bone mineral density measurements.

Results:

Bone loss in the lower part of the left mandibular molar region (standard site) decreased significantly with age ($p<0.001$) and paralleled that of the forearm. Bone loss in premolar regions was not significant over 5 years of follow up and was significantly different from that at the standard site ($p<0.001$). After correcting for age effects it was shown that in the premolar region there was a significant gain in bone mineral content ($p<0.05$). Bone loss effects were independent of attachment system. An analysis of bone loss in post menopausal females in relation to the bone mineral content at baseline suggested that those with the lowest bone mineral content pre-treatment had the greatest bone loss post implantation ($p<0.01$). The authors' concluded that implant treatment with overdentures seems to minimise mandibular bone loss, an effect that is independent of the attachment system. Osteoporosis prior to implantation may be a risk factor for bone loss around the implant but this is an indicator for maximising oral hygiene and other possible interventions, rather than a contraindication of implantation.

Comments:

Evidenced Based Healthcare Table Dental Implants

Reference: Minsk L, Polson AM 1998 **Reference No: 42**

Setting: University clinic

Design Score: 3

Design Category: Non-analytic studies

Design Notes: Case series

Intervention:

Implant survival, effect of hormone replacement therapy (HRT) on outcome

Participants:

Woman receiving implants over the age of 50.

	Control Group	Treatment Group
Age		
Number of patients		116
Number of implants		450

Follow up: Apparently up to 9 years

Inclusions:

Women over 50 years of age receiving implants over 7 years from 1989 and currently being followed at time of writing

Exclusions:

None of the patients had a history of parathyroid disease, long term use of steroids or any metabolic disorder affecting bone metabolism or wound healing.

Selection notes:

380 consecutive patients, 116 over 50 years of whom 25 (21%) were receiving HRT.

Outcome measures:

Implant failure in relation to HRT treatment

Results:

Twenty five (21%) patients were on HRT. They found HRT to have no clinically significant effect on implant survival. No statistics were presented.

Comments:

Evidenced Based Healthcare Table Dental Implants

Reference: Attard NJ, Zarb GA 2002 **Reference No: 43**

Setting: University clinic

Design Score: 2+

Design Category: 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

Design Notes: A non randomized case control study

Intervention:

Implantation (Branemark) in hypothyroid patients

Participants:

Hypothyroid patients (medically controlled) and matched controls who received implants

	Control Group	Treatment Group
Age		
Number of patients	29	21
Number of implants	81	82

Follow up: Up to 19 years

Inclusions:

Hypothyroid patients selected from a data base and matched with 29 controls. Matching was for age, gender, location of implant, type of prosthesis and dental status in opposing arch. All patients were female.

Exclusions:

Not stated in this paper

Selection notes:

27 hypothyroid patients selected from a database, 21 presented. All 29 controls selected presented for review.

Outcome measures:

Implant survival , hypothyroid status and other medical conditions

Results:

There was no statistical difference in failure rate between the hypothyroid group and the controls (p=0.781). The hypothyroid group had more soft tissue complications (p=0.018) following stage one surgery but these were minor in nature. More bone loss around the implants occurred after 1 year in the hypothyroid group (p=0.017).

Comments:

Evidenced Based Healthcare Table Dental Implants

Reference: Khadivi V, Anderson J, Zarb GA. 1999 **Reference No: 44**

Setting: University clinic

Design Score: 2-

Design Category: Case control or cohort studies with a high risk of confounding, bias or chance and a significant risk that the relationship is not causal.

Design Notes: A non randomised case control-like study of case series data. Patients were divided into 3 groups based on medical history; healthy subjects, presence of cardiovascular disease and other systemic disease.

Intervention:

Effect of cardiovascular disease (hypertension, myocardial infarction, angina, mitral valve prolapse) on implant (Branemark) survival.

Participants:

Patients receiving implants. Mean age for the 153 women was 49.8 y and for the 93 men, 46.7 y.

	Control Group	Treatment Group	Follow up:
Age			
Number of patients			
Number of implants			

Inclusions:

Patients were given implants based on dental need. No patient was rejected because of a history of cardiovascular disease.

Exclusions:

Not stated

Selection notes:

All patients on database. Of 246 patients, 59 had cardiovascular disease, 39 of whom with a diagnosis considered relevant to the objectives of the study; The remaining 20 were added to a group with 'other systemic disease'. There were 98 healthy subjects and a total of 109 patients with 'other systemic disease'.

Outcome measures:

Implant survival

Results:

The failure rates were 12.8%, 12.2% and 13.8 % respectively for the cardiovascular, healthy and 'other systemic diseases' groups. These differences were not significant.

Comments:

Other than medical history no criteria were applied to selection. The author's acknowledged the low power of the sample.

Evidenced Based Healthcare Table Dental Implants

Reference: Esposito M, Hirsch JM, Lekholm U, Thomsen P. 1998. (2 papers) **Reference No: 12 & 45**

Setting: Review of data

Design Score: 2-

Design Category: Case control or cohort studies with a high risk of confounding, bias or chance and a significant risk that the relationship is not causal.

Design Notes: Systematic-like review of studies of varying design quality. The paper is not either a full systematic review though nor a meta-analysis.

Intervention:

Dental implants (Branemark only). Effect of biological factors on implant failure.

Participants:

Papers reporting biological failure rates in patients receiving Branemark implants

	Control Group	Treatment Group	Follow up:
Age			
Number of patients			
Number of implants		2812	

Inclusions:

Papers where Branemark implants were used and biological failures reported.

Exclusions:

Papers were excluded for the following reasons-
No detailed information on the distribution of implants between jaws,
No information on when the implant failed or if the follow up period was not stated. Patients with irradiated jaws were omitted from analysis on general survival of implants,
Prototype studies.

Selection notes:

159 papers identified up to 1997. 73 met the inclusion criteria.

Outcome measures:

Failure rate

Results:

Biologically related implant failure in a total of 2,812 implants was 7.7% over a 5-year period (bone graft cases excluded). In partially edentulous patients the failure rate was about half that of totally edentulous subjects (3.8%). The failure rate of implants in bone graft situations was much higher (14.9%). Failure in the maxilla was about 3 times that of the mandible except for the partially edentulous situation where there were similar rates of failure. No statistics were presented but data was aggregated to obtain means and percentages.

Their review also identified the following factors related to patient selection to be associated with biological failures; medical status of patient, smoking, bone quality, bone grafting, parafunctions and irradiation therapy. Except for irradiation therapy no synthesis of data was made to justify this comment. A simple meta-analysis of data was provided for the effect of irradiation therapy. Based on seven studies the failure rate in the maxilla was 29 of 99 implants (29.2%), and in the mandible 19 of 386 implants (4.9%) (Some of these patients had also received hyperbaric oxygen therapy). Based on 6 studies the effect of total irradiation dose was calculable. Doses less than 55Gy, resulted in a total failure rate of 2 implants in 75 (2.6%), and for greater than or equal to 55 Gy the rate was 35 in 347 (10.1%); All implants had been placed about 9 months or more after irradiation therapy.

Comments:

It appears that the paper is not a true systematic review as all papers regardless of design quality were included an no attempt was made to weigh the evidence by the quality of the design. It is seems likely that the patient groups were heterogeneous.

Evidenced Based Healthcare Table Dental Implants

Reference: Weischer T, Mohr C. 1999 **Reference No: 46**

Setting: University clinic

Design Score: 2-

Design Category: Case control or cohort studies with a high risk of confounding, bias or chance and a significant risk that the relationship is not causal.

Design Notes: Non randomised case control. There was no attempt to match the 2 groups. Appears to be an examination of case series data where patients were retrospectively divided into 2 groups on the basis or whether or not irradiation of the jaw bone had occurred.

Intervention:

Survival of implants in patients previously irradiated for oral cancer. Comparison with non-irradiated patients. Comparison of complications with prostheses supported on implants, and implants and tissue.

Participants:

Irradiated (soft tissue and bone) and non-irradiated (only soft tissue irradiated) patients treated for oral cancer and requiring implant or implant-tissue supported prostheses.

	Control Group	Treatment Group	Follow up: 37 m
Age	56	55	
Number of patients	22	18	
Number of implants	92	83	

Inclusions:

Oral cancer with and without irradiation

Exclusions:

Not stated

Selection notes:

Outcome measures:

Adjusted survival rate

Results:

Initially some patients received prostheses supported on implant and tissue, a technique later abandoned to avoid soft tissue ulcers. The adjusted cumulative success rate after this change of strategy was 86% in the irradiated group and 94% in the non-irradiated after 5 years. The authors' concluded that the irradiated patients should only receive exclusively implant-supported prostheses to avoid problems with ulceration where the prosthesis rests partly on implant and partly on tissue.

Comments:

Evidenced Based Healthcare Table Dental Implants

Reference: Rogers MA, Figliomeni L, Baluchova K, et al, 2002 **Reference No: 47**

Setting: Hospital clinic

Design Score: 2-

Design Category: Case control or cohort studies with a high risk of confounding, bias or chance and a significant risk that the relationship is not causal.

Design Notes: Non randomised case control

Intervention:

Frequency of polymorphisms in the interleukin (IL)-1 loci, [IL-1A(-889), IL-1B(+3953) alleles, and a composite genotype IL-1A (-889)2 plus IL-1B(+3953)2]. Relation to implant failure.

Participants:

Patients with failed and successful dental implants and healthy individuals.

	Control Group	Treatment Group	Follow up: Not stated
Age			
Number of patients	60	119	
Number of implants			

Inclusions:

Not specifically stated

Exclusions:

Not stated

Selection notes:

19 patients with failed dental implants, 31 with successful implants, 69 with periodontitis and 60 healthy individuals.

Outcome measures:

Frequency of allelic distribution. Comparison between groups

Results:

IL-1A (-889), IL-1B(+3953) or the composite genotype showed no association with failure of dental implants.

Comments:

Evidenced Based Healthcare Table Dental Implants

Reference: Wang IC, Reddy MS, Geurs NC, Jeffcoat MK 1996 **Reference No: 48**

Setting: University clinic

Design Score: 3

Design Category: Non-analytic studies

Design Notes: Analysis of prospective case series data.

Intervention:

Dental implant (Steri-Oss) survival. Risk factors associated with survival

Participants:

Patients with edentulous regions, who had poor bone quality at implant site but still able to receive an implant.

	Control Group	Treatment Group	Follow up: 3 y
Age		47.2 y	
Number of patients		30	
Number of implants		83	

Inclusions:

Recipient site of poor bone quality but able to take implant.
Free from caries and active periodontitis or willing to be treated for caries and other dental needs.

Exclusions:

History of heart disease, any condition requiring antibiotic treatment, a bleeding disorder, IDDM, pregnancy, nursing a baby or of child bearing age without use of birth control, regular use of aspirin etc., significant active disease, history of neoplasia etc., any other serious medical condition.

Selection notes:

Case series data only

Outcome measures:

Implant failure analysed for contributing factors.

Results:

Thirteen of 83 implants (15.6%) failed prior to loading. They found that the presence of infection was significantly related to implant failure ($p<0.001$).

Comments:

Evidenced Based Healthcare Table Dental Implants

Reference: Polizzi G, Grunder U, Goene R, et al. 2000. **Reference No: 49**

Setting: 12 clinics, University and private

Design Score: 3

Design Category: Non-analytic studies

Design Notes: Prospective multicentre case series trial

Intervention:

Placement of implant (Branemark) either immediately into the extraction socket or after 3 to 5 weeks of healing. Survival rate and factors related to survival.

Participants:

Patients requiring dental implants after tooth extraction

	Control Group	Treatment Group	Follow up: 5 y
Age			
Number of patients		143	
Number of implants		264	

Inclusions:

Not stated in this paper

Exclusions:

Not stated in this paper

Selection notes:

143 consecutive patients. 57 (40%) were lost to follow up but data on implant loss was included if known before dropout.

Outcome measures:

Implant survival, factors related to survival

Results:

The 5 year survival rate in a total of 143 consecutive patients was 92.4% for the maxilla and 94.7% for the mandible. The authors' considered that there was a clinical correlation between implant failure and periodontitis as a reason for tooth extraction but this was not statistically significant.

Comments:

A high dropout rate occurred.

Evidenced Based Healthcare Table Dental Implants

Reference: Becktor JP, Eckert SE, Isaksson S, Keller EE. 2002 **Reference No: 50**

Setting: A Mayo Clinic

Design Score: 3

Design Category: Non-analytic studies

Design Notes: Retrospective case series

Intervention:

Implants (Branemark) in the maxillae after bone grafting. Influence of opposing dentition on implant survival

Participants:

Patients having implants in the maxilla after autogenous bone augmentation

	Control Group	Treatment Group	Follow up: Mean 64.2 m
Age		Average 57.4y	
Number of patients		90	
Number of implants		643	

Inclusions:

Requirement for autogenous bone augmentation prior to endosseous implants in the maxilla

Exclusions:

Patients with combined infection and dehiscence of the wound because of the use of a non resorbable membrane (3 patients), maxillary discontinuity due to gunshot wounds or malignancy (2), relocation before treatment completed (3) and death (3).

Selection notes:

Of 101 subjects, 11 were excluded as above.

Outcome measures:

Implant survival analysis as effected by mandibular dentition

Results:

Over a mean follow up period of 64 months the cumulative failure rate was 20.2%. They found that failure was significantly related to mandibular dentition ($p<0.001$). Mandibular dentition that leads to force concentration on the implant predisposes to failure. Implants placed opposing unilateral occlusal support were 3.6 (95% CI, 1.3 - 9.7), 4.6 (1.1 - 19.2) and 12.3 (3.1 - 48.1) times more likely to fail than implants place opposing either bilateral occlusal support, an implant supported prosthesis or a removable denture, respectively.

Comments:

Evidenced Based Healthcare Table Dental Implants

Reference: Attard NJ, Zarb GA, 2003 **Reference No: 52**

Setting: University clinic

Design Score: 3

Design Category: Non-analytic studies

Design Notes: Case series

Intervention:

Implants (Branemark) in posterior positions. Implant outcome and host determinants.

Participants:

Patients edentulous in posterior positions

	Control Group	Treatment Group	Follow up: 15 y
Age		51 y	
Number of patients		130	
Number of implants		432	

Inclusions:

Multiple missing teeth, adequate bone for implants, able to undergo minor surgery, controlled medical conditions.

Exclusions:

Not further stated

Selection notes:

Consecutive series

Outcome measures:

Implant survival rate, correlations with patient conditions etc

Results:

The 15 year survival rates were respectively for the implant and prosthesis 91.6% and 89%. Percentage of failures in the maxilla was 10.2% and 18.7% in the mandible. Wide platform implants had a lower survival rate (76.3% at 5 years). Survival was correlated with implant diameter (p=0.0001) and a history of chronic medical conditions (p=0.01). The authors concluded that implant supported fixed partial dentures were a suitable treatment option for replacing posterior teeth.

Comments:

Evidenced Based Healthcare Table Dental Implants

Reference: Shugars DA, et al 1998 **Reference No: 53**

Setting: Investigations from three databases (Veterans Affairs, Pemanente and Truman Medical)

Design Score: 2-

Design Category: Case control or cohort studies with a high risk of confounding, bias or chance and a significant risk that the relationship is not causal.

Design Notes: An analysis of the separate and combined case series data from 3 databases.

Intervention:

Untreated, removable partial dentures and fixed partial dentures in patients with posterior bounded edentulous spaces.

Participants:

Patients with posterior bounded edentulous spaces

	Control Group	Treatment Group	Follow up: Median of at least 4.2 y
Age			
Number of patients		486	
Number of implants			

Inclusions:

Case selection from the 3 data sources were;
Extraction of first molar or second premolar with adjacent teeth be documented
At time of extraction the participant had a total of fewer than 5 missing teeth
The patient record covered at least 3 years post extraction.

Exclusions:

Not further stated

Selection notes:

Data sources were selected for completeness of information or ready availability of patient records.

Outcome measures:

Survivor function curves, proportional hazards regression analysis

Results:

In total there were 486 subjects with 569 bounded edentulous spaces (BES), with median follow up ranging from 4.5 to 13.5 years depending on database. Mean percentage failures of at least one tooth adjacent to a BES ranged from 12 to 19% (depending on database) in those patients who were untreated, 2 to 10% in those who had a fixed partial denture installed and 17 to 22% in those with a removable partial denture. An analysis of the data by separate database and when combined showed that the survival curves for the removable partial denture group and untreated group were not significantly different from each other. Both were significantly different from the survival curve for the fixed partial denture group (p=0.009, p=0.01 respectively). The authors concluded that contrary to popular belief there was little evidence to support the idea that posterior BES should be restored to prevent loss of additional teeth. Given the selection bias introduced in using case series data, the extent to which treatment with fixed partial dentures improved tooth survival was not as dramatic as commonly assumed.

Comments:

The study appears to be a sophisticated analysis of case series data. Limitations of the analysis were considered in the paper and the conclusions suitably cautious. However it is not clear how many of those with fixed or removable partial dentures had them anchored on implants.

Evidenced Based Healthcare Table Dental Implants

Reference: Priest G 1999 **Reference No:** **54**

Setting: Private practice clinic

Design Score: 3

Design Category: Non-analytic studies

Design Notes: Retrospective case series

Intervention:

Single tooth implants. Role in preserving remaining teeth.

Participants:

Patients receiving single tooth implants

	Control Group	Treatment Group	Follow up: 6 m to 10y
Age			
Number of patients		99	
Number of implants		116	

Inclusions:

Implants (a range of systems used) restored and functioning for at least 6 months and patient seen within last year by the

Exclusions:

Not stated

Selection notes:

Case series

Outcome measures:

Analysis of implant failure rate

Results:

Of the 196 teeth adjacent to edentulous spaces 156 (79.6%) were initially intact or minimally restored. Over the 10 year period of the study, of these 196 adjacent teeth only one tooth required replacement restoration and one tooth was extracted. The author concluded that teeth adjacent to single tooth implants have an extremely low complication rate

Comments:

Evidenced Based Healthcare Table Dental Implants

Reference: Cochran DL. 1999 **Reference No: 55**

Setting:

Design Score: 2+

Design Category: 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

Design Notes: Systematic review with meta-analysis but data presumably comes mainly from case series studies.

Intervention:

Dental implants, survival analysed by jaw and type of implant (smooth surface, rough, hydroxyapatite).

Participants:

Papers reporting outcomes from dental implantation.

Control Group **Treatment Group** **Follow up:** 0.08 - 20 y

Age

Number of patients

Number of implants

Inclusions:

Articles to 1997, in peer reviewed, English language papers in major literature databases and secondary sources (see Table below)

Exclusions:

Not stated

Selection notes:

Not further stated

Outcome measures:

Implant survival analysed by jaw and implant surface.

Results:

Relative risk for implant loss in the maxilla compared to the mandible was for rough surfaced implants, 3.24 (95%CI, 2.82-3.71, P< 0.001) and for smooth surfaced implants, 3.02 (95% CI, 2.80-3.25, P< 0.001). For subjects though that were partially edentulous, had single crowns or hydroxyapatite coated implants the differences were either marginally significant or not significant.

Summary of data on papers, patients and total number of implants reviewed by Cochran, 1999.

Category	Number of papers	Type of implant	Number of implants in the mandible	Number of implants in the maxilla
Predominately edentulous	13	Smooth surfaced	15316	8653
	1	Rough surfaced	216	0
Removable overdenture	7	Smooth surfaced	707	598
	8	Rough surfaced	2806	0
Partially edentulous	14	Smooth surfaced	2200	2880
	7	Rough surfaced	396	272
Single crown	10	Smooth surfaced	97	520
	2	Rough surfaced	110	79
Multiple indications	18	Smooth surfaced	8940	6253
	14	Rough surfaced	8064	4304
	12	Hydroxyapatite	7222	5266

Comments:

Literature search appeared to be well done although databases searched were not described. Analysis did not take account of length of follow up. Criteria for success of implants were not analysed for each paper.

Evidenced Based Healthcare Table Dental Implants

Reference: Becker W, Becker BE, Alsuwyed A, Al-Mubarak S 1999 **Reference No: 56**

Setting: Private practice

Design Score: 3

Design Category: Non-analytic studies

Design Notes: Case series data

Intervention:

Implant (Branemark) survival in in molar positions. Comparison of survival in the mandible and the maxilla.

Participants:

Partially or completely edentulous patients

	Control Group	Treatment Group	Follow up: 3.9
Age		31 - 79 y	
Number of patients		212	
Number of implants		282	

Inclusions:

All patients receiving implants on database

Exclusions:

Poorly controlled diabetes, recent history of coronary disease, and heavy smokers.

Selection notes:

Case series data

Outcome measures:

Implant survival by jaw location

Results:

The 6 year cumulative success rates in the maxilla and mandible were 82.9% and 91.5%. The authors believe this to be less than that observed for anterior segments.

Comments:

The relative risk of implant failure in the maxilla compared to the mandible in molar regions was 2.02 (95%CI, 1.02 - 3.98).

Evidenced Based Healthcare Table Dental Implants

Reference: Lindh T, Gunne J, Tillberg A, Molin M 1998 **Reference No: 57**

Setting:

Design Score: 1-

Design Category: Meta analyses, systematic reviews of RCTs or RCTs with a high risk of bias

Design Notes: A meta-analysis

Intervention:

Fixed partial dentures or single crowns, failure rate.

Participants:

Patients with fixed partial dentures or single crowns

	Control Group	Treatment Group	Follow up: 1 - 8 y
Age			
Number of patients			
Number of implants		2686	

Inclusions:

Well defined criteria for inclusion of papers were; In English in a refereed journal, Use of threaded cylindrical metallic intraosseous implants, 1 year or more of loading, implant failure defined and cumulative survival rate was calculable. Literature search was from 1980 to 1996.

Exclusions:

Not stated

Selection notes:

66 studies found. Nineteen papers met the inclusion criteria; a total of 2686 implants in 570 single crowns and 2116 fixed partial dentures. Of these 9 studies were included that investigated fixed partial dentures, nine single crowns and one both.

Outcome measures:

Suvival analysis at one year or more.

Results:

Survival analysis showed a 85.7% success rate at one year for fixed partial dentures and 97.2% for single crowns. Lindh compared his results with those of a study published in 1986 by Albrecktsson who reported survival rates of implants in completely edentulous jaws: Success rates were very similar. An independent DARE review of this paper concluded there was strong evidence for restoring partially edentulous jaws with implants.

Comments:

The study had well defined inclusion criteria.

Evidenced Based Healthcare Table Dental Implants

Reference: Eckert SE, Wollan PC, Ardekian L, Dodson TB. 1998 **Reference No: 58**

Setting: Mayo Clinic

Design Score: 3

Design Category: Non-analytic studies

Design Notes: Case series

Intervention:

Implants supporting fixed partial dentures in partially edentulous jaws (mostly Branemark)

Participants:

Partially edentulous patients with implant supported fixed partial dentures.

	Control Group	Treatment Group	Follow up: Up to 12 y
Age		Range, 12.8 - 88.4 y	
Number of patients		445	
Number of implants		1170	

Inclusions:

Partially edentulous patients, implant prosthesis completed before March 1997, all work done at Mayo Clinic, natural teeth remain in jaw in which implants were placed.

Exclusions:

None applied

Selection notes:

Patients meeting criteria, selected from records.

Outcome measures:

Complications in relation to anatomic location and patient variables

Results:

Location of implant had no effect on implant survival, fracture rate, screw loosening or screw fracture. Implant survival was also not effected by age or gender and was similar for maxillary locations compared to mandibular (96.3% v 95.4%). The authors concluded that implant survival in partially edentulous patients was independent of anatomic location. Statistical analysis was conducted but all results were non significant.

Comments:

Evidenced Based Healthcare Table Dental Implants

Reference: Naert et al, 2002 **Reference No: 59**

Setting: University clinics

Design Score: 3

Design Category: Non-analytic studies

Design Notes: Case series

Intervention:

Implant (Branemark) and prosthesis survival in partially edentulous jaws. In 170 sites membranes or grafts were used.

Participants:

Partially edentulous patients

	Control Group	Treatment Group	Follow up: Mean 5.5 y
Age		50.5 y	
Number of patients		660	
Number of implants		1956	

Inclusions:

No restriction applied as long as patient could benefit from the use of implants

Exclusions:

Not stated

Selection notes:

660 patients and 1956 implants were placed. A total of 73 (11%) patients, (204 implants) dropped out.

Outcome measures:

Implant and prothesis survival; relation to various factors

Results:

Cumulative survival rate was 91.4% for all implants and 95.8% for all restorations. The estimated hazard rate in the mandible was 0.66 that of the maxilla (95% CI, 0.42-1.03) but this was not significant. The effect of location within the jaw was not significant. When use of a membrane or grafting was required the risk of failure increased 4.4 times, ($p<0.001$). Prostheses were not significantly more likely to fail in the maxilla compared to the mandible.

Comments:

Evidenced Based Healthcare Table Dental Implants

Reference: Scurria MS, Morgan ZVt, Guckes AD, Li S, Koch G. 1998 **Reference No:** **61**

Setting: University clinic

Design Score: 3

Design Category: Non-analytic studies

Design Notes: Case series data

Intervention:

Dental implant survival rate; Factors related to survival.

Participants:

Edentulous patients

	Control Group	Treatment Group	Follow up: 3.9 y
Age		60.5 y	
Number of patients		99	
Number of implants		384	

Inclusions:

Not stated

Exclusions:

Not stated

Selection notes:

Consecutive series

Outcome measures:

Survival analysis, Proportional hazards modelling.

Results:

In a total of 384 implants at a mean time of 3.9 years the overall failure rate was 8.9%. Failure was significantly associated with posterior locations ($p<0.05$) and implant width less than 4 mm ($P<0.05$). Failure rates in the anterior and posterior mandible, and in the anterior and posterior maxilla were respectively 6.4%, 13.2%, 9.1% and 16.3%.

Comments:

Evidenced Based Healthcare Table Dental Implants

Reference: Orenstein IH, Petrazzuolo V, Morris HF, Ochi S 2000 **Reference No: 62**

Setting: 30 Dept of Veterans Affairs Clinics 2 University clinics. A DICRG study

Design Score: 3

Design Category: Non-analytic studies

Design Notes: A cohort study.

Intervention:

Single tooth hydroxyapatite coated implants in anterior maxillae. Survival analysis.

Participants:

Veterans requiring single tooth implants in the maxillae.

	Control Group	Treatment Group	Follow up: 3 y
Age			
Number of patients		149	
Number of implants		222	

Inclusions:

Have one or more anterior maxillary teeth missing
Benefit from participating in study
Adequate bone structure
Able to understand scope of study etc
Available for follow up and show acceptable levels of oral hygiene.

Exclusions:

An extensive list of exclusions were applied including medical conditions limiting life expectancy, IDDM, certain behaviour patterns and some dental conditions such as poor dental hygiene, bruxism, a history of necrotizing ulcerative gingivitis and any infections in the mouth. (see Implant Dent 1992;1:49-55).

Selection notes:

Data on 247 implants was available in database. 222 implants had 3 year follow up data.

Outcome measures:

Survival analysis, correlation with other variables

Results:

In a total of 222 implants they found a survival rate at that time of 97.3%. Survival correlated with length of implant (p=0.003). The authors concluded that endosseous implants to support maxillary anterior single-tooth implants is a predictable and reliable procedure.

Comments:

Evidenced Based Healthcare Table Dental Implants

Reference: Awad MA, Lund JP, Dufresne E, Feine JS, 2003; and Awad M et al, 2000. **Reference No: 63 & 70**

Setting: University clinic

Design Score: 1+

Design Category: Well conducted meta analyses, systematic reviews of RCTs, or RCTs with a low risk of bias

Design Notes: An RCT. Power calculations were made. Randomisation done by computer with stratification for age, gender and preference for treatment. No blinding or concealment. Clear inclusion criteria. Analysed on an 'intention to treat' basis.

Intervention:

Mandibular overdentures supported on 2 implants (Branemark) or conventional mandibular dentures. Both groups received a new set of conventional maxillary dentures as well. Comparison of patient satisfaction.

Participants:

Edentulous patients who had worn conventional dentures for at least 10 years.

	Control Group	Treatment Group	Follow up: 2 m
Age		50.3 all subjects	
Number of patients	48	54	
Number of implants	0	108	

Inclusions:

Edentulous for at least 10 years and wearing dentures on a regular basis.

Exclusions:

Inadequate mandibular bone to place 2 implants, bruxism, clenching, or temporomandibular disorders.

Selection notes:

470 subjects responded by phone. 220 attended an information session, 30 took no further part. 88 of the 190 potential subjects were rejected after an examination. 102 met eligibility criteria. After assignment to group, 4 withdrew (4%).

Outcome measures:

Measures of patient satisfaction using a 100mm VAS scale. Oral health impact profiles were also measured.

Results:

At 2 months after delivery of the prosthesis general satisfaction was significantly higher in the implant group ($p<0.0001$). On average the implant group rated satisfaction 26.5mm higher (on 100mm VAS scale). The implant group also rated satisfaction higher for comfort, stability, and ease of chewing ($p<0.05$) but there was no difference with respect to ease of cleaning, ability to speak, or aesthetics. The authors concluded that mandibular 2 implant overdentures opposed by maxillary conventional dentures is more satisfactory than conventional dentures for edentulous middle aged adults. The Oral Health Impact Profile scores were significantly lower post treatment in the implant compared to the conventional group indicating a better quality of life outcome ($p<.0.05$).

Comments:

A difference of 26.5mm is suggestive of clinical as well as statistical significance.

Evidenced Based Healthcare Table Dental Implants

Reference: Raghoebar G et al. 2000 **Reference No: 64**

Setting: University clinic

Design Score: 1-

Design Category: Meta analyses, systematic reviews of RCTs or RCTs with a high risk of bias

Design Notes: An RCT where randomisation was by a balanced allocation method. Patient characteristics between groups were not significantly different. Allocation was concealed. No blinding. Analysed on an 'intention to treat basis'.

Intervention:

Patient satisfaction with three treatment options; conventional dentures, conventional dentures after preprosthetic surgery and implant (Branemark or IMZ) retained mandibular overdentures. All patients received a new maxillary denture.

Participants:

Edentulous patients with resorbed mandibles.

	Control Group	Treatment Group	Follow up: 1 and 5 y
Age		Means, 58.2, 52.7 and 55.2 y	
Number of patients		90	
Number of implants			

Inclusions:

Edentulous at least one year and a mandibular height between 15 and 25 mm.

Exclusions:

No preprosthetic surgery or dental implants

Selection notes:

90 patients in randomised into 3 groups. At 1 year, 4 patients were lost to follow up. Eight from the conventional denture group and 4 from the preprosthetic surgery group elected to switch to implants. At 5 years 8 more were lost. The implant group at this time had 29 patients, the preprosthetic surgery group 26 and the conventional denture group 23 on the intention to treat basis.

Outcome measures:

Patient satisfaction score

Results:

After one year those with conventional dentures had scored significantly lower satisfaction scores than in the other two groups ($p<0.05$) for most items surveyed. At five years those with implant retained overdentures scored significantly better with respect to 'complaints with the lower denture' compared to those with conventional dentures ($p<0.05$).
At one year those receiving implants were more satisfied than those having preprosthetic surgery for most of the individual items surveyed. Overall patient satisfaction was not different between the implant and preprosthetic surgery groups though.
At 5 years on a 'per protocol basis' the implant group was significantly more satisfied than those without implants ($p<0.05$).
On an intention to treat basis there was no significant difference between the implant and preprosthetic surgery groups.

The authors' concluded that implant supported overdentures were the treatment of choice for patients with resorbed edentulous mandibles. They proposed a strategy where by patients with still relatively high mandibular bone would receive a complete denture first and if dissatisfied at one year would have the opportunity to have implants.

Comments:

The paper appears to report a well designed RCT.

Evidenced Based Healthcare Table Dental Implants

Reference: Kapur K et al. 1998 **Reference No: 65**

Setting: University centre and US Veteran's Hospitals

Design Score: 1-

Design Category: Meta analyses, systematic reviews of RCTs or RCTs with a high risk of bias

Design Notes: An RCT which was meticulously planned. Some dropouts occurred. Randomisation appears to have been well done as judged by a comparison of patient characteristics. Sample size calculations made. Not blinded, Not analysed on an 'intention to treat' basis.

Intervention:

Conventional mandibular dentures compared to implant supported overdentures (plastic clip retainers for a Hader bar attached to 2 IMZ implants). Patients also received a new set of maxillary dentures. Comparison of patient satisfaction

Participants:

Edentulous diabetic patients

	Control Group	Treatment Group
Age	64.2	65.7
Number of patients	37	52
Number of implants	0	104

Follow up: 6 m post installation of prosthesis.

Inclusions:

Edentulous diabetic patients >50 years old (both Type 1 and 2).

Exclusions:

Poor metabolic control, Advanced cardiovascular disease, retinopathy or renal disease, Blood dyscrasias, uncontrolled endocrine disorders, connective tissue disorders, liver dysfunction, autoimmune deficiency, active tuberculosis, psychosis, osteoporosis, anticoagulant or anticonvulsant therapy, steroid therapy, long-term radiation therapy, immnosuppressors.

Selection notes:

Orignially the 108 patients were to be randomised into 3 groups, conventional dentures, and implant supported overdentures (IOD) in insulin and non-insulin dependent diabetics, 40 to conventional dentures and 68 to the 2 experimental group. As there were no differences in baseline characteristics between the 2 experimental groups these were amalgamated for the analysis. 108 selected, 102 entered, 40 to controls and 62 experimental. 37/40 (92%) went on to receive dentures, and 52/62 (84%) IODs.

Outcome measures:

Patient satisfaction, review of maintenance

Results:

Treatment was judged successful in 56.9% of those receiving conventional dentures and 72.1% of those with implants but this difference was not significant (patients with 2 year follow up data). Patients with treatment failures required excessive maintenance care. Percentage of patients with chewing comfort and moderate to complete satisfaction was higher in those with implant supported overdentures but these differences were of marginal significance. The authors concluded that the implant supported overdenture has some advantage in terms of perceived chewing function. A related paper reports that food preferences were not altered by either intervention[89]. The authors' concluded that implant supported mandibular overdentures may be considered when patients continue to experience chronic problems with clinically acceptable conventional dentures.

Evidenced Based Healthcare Table Dental Implants

Reference: Kuboki T, Okamoto S, Suzuki H, et al 1999 **Reference No: 66**

Setting: University clinic

Design Score: 2-

Design Category: Case control or cohort studies with a high risk of confounding, bias or chance and a significant risk that the relationship is not causal.

Design Notes: Case control study of case series data. Two control groups of patients selected from the series were matched with patients with implant supported fixed partial dentures.

Intervention:

Quality of life assessment with respect to oral condition and general condition was compared in three groups of patients; those with implant (IMZ) supported fixed partial dentures (FPD), removable partial dentures (RPD) and those with no restoration (NR).

Participants:

Patients with unilateral mandibular distal-extension edentulism who had received either an implant supported fixed partial denture, a removable partial denture or no restoration.

	Control Group	Treatment Group
Age		
Number of patients		
Number of implants		

Follow up: FPD = 37.2 m, RPD = 20.8 m, NR > 2 m.

Inclusions:

Unilateral mandibular distal extension edentulism and no missing teeth on the opposing side and either FPD, RPD or NR - and had not worn a removable partial denture for more than 2 months.

Exclusions:

Not stated

Selection notes:

A questionnaire was sent to 104 selected patients who had been age and sex matched between the groups. Of the 86 patients responding 3 were excluded for incomplete data (response rate 80%). This left, FPD = 12, RPD = 46 and NR = 25. An age, sex and missing tooth matching process was repeated to give FPD = 12, RPD = 24, NR = 24.

Outcome measures:

Survey to assess quality of life with respect to oral and general factors.

Results:

Quality of life questions assessing oral condition (functional limitation, physical pain/discomfort and anxiety) were scored higher by those with dental implants (92.5, 96.3,92.2) than by those with either removable partial dentures (80.3,80.6,78.1) (P=0.006, 0.0003, 0.0058) or no restoration (79.0, 79.6, 78.6)(p= 0.0063, 0.0029, 0.008). There were no significant differences between the removable partial denture group and the no restoration group. General quality of life was not different between the three groups. The authors concluded that implant supported fixed partial dentures may promote quality of life with respect to oral condition.

Comments:

Groups were well matched with respect to a wide range of factors. Functional duration was more variable.

Evidenced Based Healthcare Table Dental Implants

Reference: de Albuquerque Junior RF, Lund JP, Tang L, et al. 2000 **Reference No: 67**

Setting: A university clinic

Design Score: 3

Design Category: Non-analytic studies

Design Notes: The study was a prospective case series for the conventional denture phase of the study followed by a crossover design to compare maxillary long-bar overdentures with and without palatal covering.

Intervention:

New conventional maxillary and mandibular dentures were trialled for a 2 month period. This was followed by installation of 4 maxillary implants, 4 mandibular implants and a 4 month healing period. (Branemark Implants). A fixed mandibular prosthesis was then installed and trialled for a 2 month period against conventionl dentures. Maxillary long-bar overdentures with and without palate were then trialled for 2, 2 month periods in a cross over design. Patient satisfaction.

Participants:

16 totally edentulous patients

	Control Group	Treatment Group	Follow up: 2m for each phase
Age		median 45 y	
Number of patients		16	
Number of implants		120	

Inclusions:

Inclusion criteria was based on quantity and quality of alveolar bone and an adequate interocclusal space.

Exclusions:

Presence of abnormalities, systemic or oral disease that would contraindicate implant surgery.

Selection notes:

After the trial of conventional dentures 1 of 16 subjects dropped out. After placement of the implants 2 more dropped out leaving 13 for the crossover trial.

Outcome measures:

General satisfaction rated on a VAS scale and category scale.

Results:

Ratings for mandibular prostheses increased when the new conventional dentures were replaced with implant prostheses and opposed by conventional maxillary dentures ($p = .032$). Significant increases in stability ($p<0.0001$) and retention ($p=0.002$) also occurred but conventional dentures were considered easier to clean ($p=.003$).

There were no signifcant differences in general satisfaction between the 3 maxillary prostheses trialled including the rating of general satisfaction between maxilliary overdentures with and without palatal covering.

The authors concluded that maxillary implant prostheses should not be considered as a general treatment of choice in patients with sufficient bony support for maxillary conventional prostheses.

Comments:

This study appears to be a well conducted trial. Although numbers are small statistically significant results were obtained.

Evidenced Based Healthcare Table Dental Implants

Reference: Walton Jn, MacEntee M. I. Glick N. 2002 **Reference No: 68**

Setting: University clinic

Design Score: 1-

Design Category: Meta analyses, systematic reviews of RCTs or RCTs with a high risk of bias

Design Notes: An RCT with balancing. Surgeons were blinded at time of implantation and randomization for prosthetic treatment took place after second-stage surgery. Comparison of the mandibular implant supported prosthesis with the previous conventional denture was essentially a pre- post case series design.

Intervention:

Mandibular denture retained with either ball or clip on 2 implants (Branemark). Patient satisfaction.

Participants:

Edentulous patients

	Control Group	Treatment Group	Follow up: 1 year
Age		64.4	
Number of patients		64	
Number of implants		128	

Inclusions:

Edentulous patients with at least one years experience with conventional complete dentures, medically and psychologically suited, able to complete forms and communicate in English and availble for the duration of the study.

Exclusions:

Insufficient bone height for an 8.5 mm mandibular implant, history of head and neck radiation, systemic or neurological diseases, previous implants or need of preprosthetic surgery.

Selection notes:

100 subjects enrolled, 67 available with at least a 1 year follow up at time of analysis. Of these 67, 64 were available for examination.

Outcome measures:

Patient satisfaction measured on a VAS scale, Clinical variables

Results:

Ball attachments required about 8 times longer to repair than bar clip prostheses ($p<0.001$) and repair was required more often ($p<0.01$). There was no difference in patient satisfaction with either ball of clip mechanisms at one year. Patient's preferred ball or clip prostheses to the previous conventional denture ($p<0.001$).

Comments:

A well conducted RCT. Analysing the data at the time chosen meant a large dropout rate.

Evidenced Based Healthcare Table Dental Implants

Reference: Leung AC, Cheung LK. 2003 **Reference No: 69**

Setting: University clinic

Design Score: 3

Design Category: Non-analytic studies

Design Notes: Survey of patients

Intervention:

Dental implants (Branemark, IMZ, Calcitek) after bone grafting. Patient satisfaction with treatment.

Participants:

Patients treated with bone grafts prior to implantation

	Control Group	Treatment Group	Follow up: > 6 m
Age		35.8	
Number of patients		28	
Number of implants		134	

Inclusions:

Patients treated for various cancers and other diseases who required bone grafts prior to implantation.

Exclusions:

Less than 6 months after rehabilitation. Psychologic contraindications.

Selection notes:

46 cases in database. 28 met inclusion criteria, 14 with maxillary reconstructions and 14 mandibular.

Outcome measures:

Patient satisfaction survey

Results:

Overall satisfaction was high (greater than 8/10) for a range of variables including appearance and function. Satisfaction was not related to age, jaw or gender.

Comments:

Evidenced Based Healthcare Table Dental Implants

Reference: Awad MA, Lund JP, Dufresne E, Feine JS, 2003; and Awad M et al, 2000. **Reference No: 63 & 70**

Setting: University clinic

Design Score: 1+

Design Category: Well conducted meta analyses, systematic reviews of RCTs, or RCTs with a low risk of bias

Design Notes: An RCT. Power calculations were made. Randomisation done by computer with stratification for age, gender and preference for treatment. No blinding or concealment. Clear inclusion criteria. Analysed on an 'intention to treat' basis.

Intervention:

Mandibular overdentures supported on 2 implants (Branemark) or conventional mandibular dentures. Both groups received a new set of conventional maxillary dentures as well. Comparison of patient satisfaction.

Participants:

Edentulous patients who had worn conventional dentures for at least 10 years.

	Control Group	Treatment Group	Follow up: 2 m
Age		50.3 all subjects	
Number of patients	48	54	
Number of implants	0	108	

Inclusions:

Edentulous for at least 10 years and wearing dentures on a regular basis.

Exclusions:

Inadequate mandibular bone to place 2 implants, bruxism, clenching, or temporomandibular disorders.

Selection notes:

470 subjects responded by phone. 220 attended an information session, 30 took no further part. 88 of the 190 potential subjects were rejected after an examination. 102 met eligibility criteria. After assignment to group, 4 withdrew (4%).

Outcome measures:

Measures of patient satisfaction using a 100mm VAS scale. Oral health impact profiles were also measured.

Results:

At 2 months after delivery of the prosthesis general satisfaction was significantly higher in the implant group ($p<0.0001$). On average the implant group rated satisfaction 26.5mm higher (on 100mm VAS scale). The implant group also rated satisfaction higher for comfort, stability, and ease of chewing ($p<0.05$) but there was no difference with respect to ease of cleaning, ability to speak, or aesthetics. The authors concluded that mandibular 2 implant overdentures opposed by maxillary conventional dentures is more satisfactory than conventional dentures for edentulous middle aged adults. The Oral Health Impact Profile scores were significantly lower post treatment in the implant compared to the conventional group indicating a better quality of life outcome ($p<.0.05$).

Comments:

A difference of 26.5mm is suggestive of clinical as well as statistical significance.

Evidenced Based Healthcare Table Dental Implants

Reference: Chang M, Odman PA, Wennstrom JL, Andersson B 1999 **Reference No: 71**

Setting: University clinic

Design Score: 3

Design Category: Non-analytic studies

Design Notes: Cross sectional survey of case series patients.

Intervention:

Patient satisfaction with single tooth implants and abutment (Branemark)

Participants:

Patients with single tooth implants

	Control Group	Treatment Group	Follow up: 3 y
Age		32 y	
Number of patients		29	
Number of implants		41	

Inclusions:

Single implant supported crowns in the maxillary anterior region.

Exclusions:

Not stated

Selection notes:

29 patients in clinic records

Outcome measures:

Patient satisfaction with implant and crown as assessed by survey. (7 questions on VAS scale).

Results:

Appreciation with the aesthetic outcome was rated highly; All variables assessed (eg crown form, colour, satisfaction with appearance) rated greater than 90%.

Comments:

Evidenced Based Healthcare Table Dental Implants

Reference: Kaptein ML, Hoogstraten J, de Putter C, de Lange GL, Blijdorp PA. 1998 **Reference No: 72**

Setting: University clinic

Design Score: 3

Design Category: Non-analytic studies

Design Notes: Case series

Intervention:

Maxillary bone reconstruction followed by dental implants (IMZ). Patient satisfaction with reconstruction and implant.

Participants:

Patients with atrophic maxilla.

	Control Group	Treatment Group
Age		51.6 y
Number of patients		88
Number of implants		470

Follow up: At least 5 years

Inclusions:

Major complaints with 2 or more maxillary dentures and secondary complaints about the effect on social activity and self confidence, dental aversion leading to vomiting chewing, speech or aesthetic difficulties.

Exclusions:

ASA score of 3 to 5.

Selection notes:

Outcome measures:

Patient satisfaction scores, 1 = bad, 5 = very good.

Results:

Five year implant survival was 82%. Patients scored their total treatment 4.1 out of 5 ($p<.001$), a score the authors considered acceptable.

Comments:

Evidenced Based Healthcare Table Dental Implants

Reference: Naert I et al, 1999 **Reference No: 73**

Setting: University clinics

Design Score: 1-

Design Category: Meta analyses, systematic reviews of RCTs or RCTs with a high risk of bias

Design Notes: Well designed RCT with relatively small numbers of patients. Not blinded. Patient characteristics suggested that the 3 groups were well balanced.

Intervention:

Mandibular overdentures retained on 3 systems (ball, magnet and bar (Dolder bar with continuous clip)) on Branemark Implants

Participants:

36 edentulous patients

	Control Group	Treatment Group	Follow up: 5 y
Age		63.7	
Number of patients			
Number of implants			

Inclusions:

Edentulous for more than a year and complaining about their existing lower dentures.

Exclusions:

Insufficient bone volume, angle class 2 jaw relationship, psychological problems for accepting removable dentures, gagging reflexes, less than 1 year of edentulism in the mandible, absence of a maxillary complete denture and administrative or physical considerations.

Selection notes:

36 patients randomised into 3 groups of 12 (ball, bar, magnet). 5 dropped out at various times.

Outcome measures:

Complications, patient satisfaction

Results:

The bar retained mandibular overdentures had the highest retention capacity and least prosthetic complications but caused more mucositis and gingival hyperplasia. Patient satisfaction was good with all groups but the magnet group because of lower retentive capacity scored prosthesis stability and chewing comfort lower ($p<0.05$) and general satisfaction and denture stability lower ($p<0.03$).

Comments:

A well conducted RCT. Relatively small numbers of patients.

Evidenced Based Healthcare Table Dental Implants

Reference: Moberg LE, Kondell PA, Sagulin GB, Bolin A, Heimdahl A, Gynther GW. 2001 **Reference No: 74**

Setting: University clinic

Design Score: 1-

Design Category: Meta analyses, systematic reviews of RCTs or RCTs with a high risk of bias

Design Notes: RCT, no blinding, randomisation not described.

Intervention:

Comparion of patient satisfaction etc with mandibular fixed prosthesis on the 2 stage Branemark system or the 1 stage ITI

Participants:

Patients with edentulous mandibles

	Control Group	Treatment Group	Follow up: 3 y
Age	62.6 y	64 y	
Number of patients	20	20	
Number of implants	102	106	

Inclusions:

Edentulous mandible

Exclusions:

General or local contraindications

Selection notes:

40 consecutive patients randomised into 2 groups. 3 patients died over the 3 years of follow up, 1 in the Branemark group and 2 in the ITI group.

Outcome measures:

Patient satisfaction, treatment time, complications etc

Results:

After 3 years the cumulative success rates were 97.9% and 96.8% with the Branemark and ITI systems respectively, a difference that was not statistically difference. Treatment time was similar with the 2 systems. About half of the Branemark patients reported difficulty in coping with the surgical procedures. From a therapeutic perspective there were only minor differences between the 2 systems.

Comments:

Appears to be a well conducted RCT that showed little therapeutic difference between the systems. Many patients expressed dissatisfaction with the surgery associated with the Branemark system

Evidenced Based Healthcare Table Dental Implants

Reference: Meijer Hj, Geertman M. E. Raghoebar G. M. Kwakman J. M. 2001 **Reference No: 75**

Setting: 2 University clinics

Design Score: 1-

Design Category: Meta analyses, systematic reviews of RCTs or RCTs with a high risk of bias

Design Notes: 3 treatment groups each receiving a particular implant system. Allocation was by a computerised balancing method. Implant system used was partially specific to a clinic though.

Intervention:

Implant retained mandibular overdentures using 3 systems: IMZ (Intra Mobiele Zylinder), Branemark or TMI (Transmandibular Implant). Patient satisfaction with system.

Participants:

Patients edentulous with severely resorbed mandibles

	Control Group	Treatment Group	Follow up: 6 years
Age			
Number of patients			
Number of implants			

Inclusions:

Edentulous in the upper or lower jaw for at least a year, problems with retention and stability of the lower denture, mandibular bone height of 8 - 15 mm.

Exclusions:

Preprosthetic surgery, a history of radiotherapy of the head and neck region or general medical contraindications.

Selection notes:

41 received IMZ, 17 Branemark and 29 TMI

Outcome measures:

Implant failure, performance factors and patient satisfaction

Results:

Implant survival rate was no different at 1 year but at 6 years it was significantly worse in the TMI group. (72% cf to 97.5% and 97.1% in the other 2 groups). At 6 years patient satisfaction was least for the IMZ system; This difference was significant ($P<0.05$). The authors concluded that the TMI implant was not the system of choice for patients with edentulous mandibles with a height between 8-15mm due to a poorer success rate.

Comments:

Since the type of implant system used was not randomized between the clinics the validity of the study is questionable.

Evidenced Based Healthcare Table Dental Implants

Reference: Sonoyama W, Kuboki T, Okamoto S, et al. 2002 **Reference No: 76**

Setting: University clinic

Design Score: 2-

Design Category: Case control or cohort studies with a high risk of confounding, bias or chance and a significant risk that the relationship is not causal.

Design Notes: Survey of 2 groups, selected from a consecutive series.

Intervention:

Implant supported fixed prosthesis , and resin-bonded fixed prosthesis; Comparison of quality of life.

Participants:

Patients with bounded edentulous spaces who had either a resin-bonded prosthesis or an implant supported prosthesis

	Control Group	Treatment Group
Age	48.1y	44.1 y
Number of patients	33	11
Number of implants		

Follow up: 12..5 m implant group, 21.2 m resin-bonded group

Inclusions:

For the implant supported group,
Loss of one or two teeth resulting in a bounded edentulous state (BES)
Restoration with implant-supported fixed prosthesis without connection to adjacent teeth
Absence of a resin-bonded prosthesis in the mouth
For the resin-bonded group,
Loss of 1 or 2 teeth resulting in a BES
Restoration with a resin-bonded prosthesis
Absence of an implant-supported prosthesis.

Exclusions:

Not otherwise stated

Selection notes:

61 patients selected. 48 (79%) returned the questionnaire. 4 excluded because of incomplete data. This left 11 in the implant group and 33 in the resin-bonded group.

Outcome measures:

Quality of life assessment relating to oral condition and general condition

Results:

The mean QOL scores measuring 'oral condition' were 87.8 and 87.1 in the implant supported and resin-bonded groups respectively. Mean 'general condition' scores were respectively 73.8 and 71.6. Neither of these differences were significant. Average direct treatment cost of the implant supported prosthesis was $US2236 compared to $US296 for the resin-bonded group.

Comments:

The groups were well matched with respect to a range of variables but the duration of functional use was significantly different, 21 months in the resin-bonded group and 12.5 months in the implant group. Allocation was not randomised in any way.

Evidenced Based Healthcare Table Dental Implants

Reference: Heydecke G, 2003 **Reference No: 77**

Setting: University clinic

Design Score: 2-

Design Category: Case control or cohort studies with a high risk of confounding, bias or chance and a significant risk that the relationship is not causal.

Design Notes: Originally designed as a crossover trial, because a significant period effect was observed the study was confined to the first period only. In effect a simple non randomised controlled study.

Intervention:

Patient satisfaction with maxillary implant retained (4 to 6 implants, Branemark) fixed prostheses (FP) compared to removable overdentures retained by a long parallel bar (LBO). These were opposed by mandibular implant - supported overdentures.

Participants:

Edentulous patients dissatisfied with conventional dentures

	Control Group	Treatment Group	Follow up: 2 months with prostheses
Age		45.1(all patients)	
Number of patients	5	8	
Number of implants			

Inclusions:

Edentulous patients with chronic problems with conventional dentures, Inclusion criteria were based on quantity and quality of alveolar bone and an adequate interocclusal space.

Exclusions:

Presence of abnormalities, systemic or oral disease that would contraindicate implant surgery.

Selection notes:

16 recruited, 3 dropped out from the LBO group due to implant failure and poor health. This left 5 who received LBO and 8 the FP

Outcome measures:

Patient satisfaction as assessed with various tests

Results:

Removable long-bar overdentures received higher ratings of general satisfaction than fixed prostheses (p= 0.003), and also scored, ability to speak (p=0.036) and ease of cleaning higher (p=0.004). The authors concluded that the long-bar overdentures appear to provide patients with better speech function and are easier to clean than fixed prostheses.

Comments:

There were very small numbers per group and no randomisation, but the difference in general satisfaction between the groups was 40.7 on a scale of 100: this difference may be of clinical significance.

Evidenced Based Healthcare Table Dental Implants

Reference: van der Wijk P, Bouma J, van Waas MA, van Oort RP, Rutten FF. 1998 **Reference No: 78**

Setting: Academic hospital

Design Score: 1+

Design Category: Well conducted meta analyses, systematic reviews of RCTs, or RCTs with a low risk of bias

Design Notes: An RCT. Randomised with balancing, no blinding or concealment. Analysed on an 'intention to treat' basis. Baseline comparision of groups showed no relevant differences.

Intervention:

Mandibular overdentures supported on 2 dental implants (Branemark, IMZ) compared to transmandibular implants, conventional dentures after preprosthetic surgery and conventional dentures. All patients received a new set of maxillary dentures. Cost comparison study.

Participants:

Edentulous patients

	Control Group	Treatment Group	Follow up: 1 y
Age		Group means = 53, 55, 53 and 57	
Number of patients			
Number of implants			

Inclusions:

Edentulous in both jaws for at least 12 months. Severely resorbed mandibles. Mandibular bone height of 8 to 25 mm. No general contraindications.

Exclusions:

Not further stated

Selection notes:

240 patients randomly assigned to the 4 groups at 2 centres. At Nijmegen, 3 X 30 patients received either transmandibular, standard implants or conventional dentures. All had a maximum bone height of 14mm. At Groningen, selection was made on mandibular bone height - those with bone height above 15 mm the options were standard implants, preprosthetic surgery or conventional dentures. For patients with bone height of 8 to 14 mm only conventional dentures or standard implants were available. 9 of the 240 refused the allocated treatment but were analysed on the intention to treat basis. Final numbers treated were, Transmandibular = 30, Implants = 89, Preprosthetic = 28, and new dentures = 89.

Outcome measures:

Treatment data was collected at patient level and included indirect costs, costs of materials, labour, hospital, laboratory, anaesthetics and follow up costs including treatment of complications.

Results:

Total costs over one year for transmandibular implants, standard implants, preprosthetic surgery + complete dentures, and complete dentures were respectively $7605 - $8830, $3711, $3808 and $1205. Cost of transmandibular implants were about 7 times that of conventional dentures and standard implants about 3 times. The authors considered their analysis to be robust as assessed by sensitivity analysis.

Comments:

Allocation of patients to the treatments at the 2 clinics is not well described. The interventions and inclusion criteria varied with location. This may have introduced a bias. Otherwise the study appears to be robust.

Evidenced Based Healthcare Table Dental Implants

Reference: Tinsley D, Watson CJ, Russell JL. 2001 **Reference No: 79**

Setting: A dental institute

Design Score: 1-

Design Category: Meta analyses, systematic reviews of RCTs or RCTs with a high risk of bias

Design Notes: A prospective case control study in which patients were randomly allocated to receive either a implant supported fixed prosthesis or a removeable prosthesis. Basis of randomisation was not described. No blinding, concealment, comparison of baseline parameters, or statistical analysis occurred.

Intervention:

Comparison of initial and follow up costs, visits, work time and complications of placing either implant (Calcitek, hydroxyapatite coated implants) supported fixed or removable prostheses in the mandible.

Participants:

Patients with edentulous mandibles

	Control Group	Treatment Group	Follow up: 6 years
Age		Range 37 - 80 y all subjects	
Number of patients	23	21	
Number of implants	77	104	

Inclusions:

Inability to wear a removable mandibular complete prosthesis. Residual bone height greater than 8mm and width greater than 5mm.

Exclusions:

Medically compromised, poor oral hygiene, heavy smokers, severe psychiatric disorders.

Selection notes:

48 patients were initially accepted into the study. Of the 104 implants initially placed in the 21 patients receiving the fixed prosthesis, 79 (76%) remained in the study at the 6th year. Of the 77 implants placed in 23 patients receiving the removeable prosthesis, 68 (88%) remained in the study at the 6th year.

Outcome measures:

Implant survival, complications, visits and narrative description of costs,

Results:

Over a six year period, implant failure rates were similar. Clinical time taken to construct the prosthesis was similar for the two groups, but the removable restoration cost less than half that of the fixed prosthesis when technical time and material costs were considered. Patients with removable dentures required more visits over the six years and the incidence of remakes and adjustments was also higher.

Comments:

Costing details other than the narrative description were not given and no statistical analysis was provided.