Does the Type of Implant Prosthesis Affect Outcomes for the Completely Edentulous Arch?

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Purpose: *A systematic review, including meta-analysis, was conducted to answer the question "Does the type of implant prosthesis affect outcomes for the completely edentulous arch?" The current paper was to assess the impact of fixed or removable prosthesis type on implant survival and success outcomes.* ***Materials and Methods:*** *Pertinent literature was identified through December 31, 2005 using a PubMed search strategy and hand-searching of relevant journals, a personal library, and reference lists from included studies. Inclusion and exclusion criteria were applied to the titles and abstracts and subsequently to the full text of included references. The 72 included studies reported oral implant survival or success, crestal bone levels or loss, and/or prosthesis success or maintenance differentiated by arch and by prosthesis type (fixed or removable, splinted or nonsplinted) established either in 1-year randomized clinical trials or 5-year observational studies.* ***Results:*** *Statistical analysis revealed only a site-specific rather than a design-specific finding that implant survival for mandibular fixed prosthesis groups had a 6.6% greater implant survival than maxillary fixed prostheses groups ($P < .001$). The observation of greater implant failure for removable over fixed protheses groups in the maxilla appeared likely due to deficient preoperative bone volume in the removable prosthesis groups.* ***Discussion:*** *There is little evidence that implant survival or success is affected directly by prosthesis type based on current designs studied for at least 5 years. Prosthesis maintenance does appear to vary with different prosthesis designs.* ***Conclusion:*** *While this study suggests implant survival and success may not be affected by variation across the established types of implant prostheses, maintenance demands can vary with implant prosthesis type, especially with overdenture attachments. Clinicians should remain diligent in basing implant prosthodontic technique on established protocols.* INT J ORAL MAXILLOFAC IMPLANTS 2007;22(SUPPL):117–139

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Various prosthetic design variables must be considered when implant prosthodontic treatment is indicated for the completely edentulous arch. One of the most fundamental of these is the selection of a fixed versus removable type; however, prostheses differ in myriad other ways (eg, splinting/and rotational characteristics, prosthetic materials, abutment designs, number and position of implants used for support). Decisions regarding all of these factors must be made in the context of the oral and systemic ecology in which the prosthesis will exist. The outcome of oral implant treatment for edentate arches has been reported in multiple publications. Of these, 72 studies[1–72] were found to report specific oral implant outcomes differentiated by arch and by type (fixed or removable and splinted or nonsplinted). Included studies were either randomized clinical trials (RCTs) at least 1 year long or prospective or retrospective cohort studies in consecutively treated arches observed for a minimum of 5 years. The long-

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term efficacy of fixed and removable dental prostheses in patients who had persistent problems wearing complete dentures has been confirmed in various studies.[2,3,8,55,73,74] The preponderance of evidence suggests that typical outcomes for implant stability in the 80% to 95% range can be achieved over 10 or more years, with mean rates of crestal bone loss less than 0.1 mm annually after the first year of function. Likewise, prosthetic maintenance and functional and psychosocial responses to complete rehabilitation of the dental arch have generally been favorable from the perspectives of both the dentist and patient.[56,60,73,74–77] Remarkably, the highly predictable results of implant treatment for total tooth loss have prompted a consensus statement suggesting the 2-implant–supported removable overdenture as the minimum standard of care for the edentulous mandible.[78] However, there remains little conclusive evidence to guide clinicians and patients as to the optimal type of prosthesis for rehabilitation of the completely edentulous maxilla or mandible.

Among the longest-term studies of outcomes for implant prostheses in the edentulous arch are Adell and colleagues,[2] with an 86% cumulative survival rate over 15 years among 480 implants placed originally to support 83 complete fixed mandibular prostheses (routine group 1), and a 78% cumulative survival rate over 15 years among 524 implants placed originally to support 80 complete fixed maxillary prostheses (routine group 1); Ekelund and associates,[15] with a 98.9% cumulative survival rate over 20 years among 273 implants placed originally to support 47 complete fixed mandibular prostheses; and Attard and Zarb,[73] with a cumulative survival rate of 86.7% over 18 to 23 years (mean, 20 years) among 265 implants (including 2 late replacements) placed originally to support 47 complete fixed prostheses and a 93.1% cumulative survival rate over 10 to 19 years (mean, 16 years) among 132 implants placed originally to support 47 complete removable overdentures.[74] The treatment groups in the latter 2 studies involved both arches but were composed primarily of mandibular arches. The fixed prostheses generally utilized acrylic resin teeth processed on splinted cast gold alloy or silver-palladium frames with bilateral cantilevers, whereas the overdentures involved acrylic resin teeth processed on acrylic resin bases retained primarily by splinted gold alloy Dolder bar-and-clip attachments, or occasionally by nonsplinted magnet or gold alloy ball-and-clip attachments. All 4 studies employed threaded, machined, root-form Brånemark system titanium implants. Similar results into the second decade of use have yet to be shown for a diversity of implant designs.

This paper forms part of the fifth of 8 systematic reviews completed for the Academy of Osseointegration's 2006 workshop The State of the Science on Implant Dentistry (SSID). Question 5, the question this review aimed to answer, was "Does the type of implant prosthesis affect outcomes for the completely edentulous arch?" The current analysis was to test the specific hypothesis that there is no difference in implant survival and success outcomes between fixed and removable prosthesis types in edentulous arches. The possible effects of other variations in prosthetic type (such as splinting, rotational characteristics, prosthetic materials, and the number of implants) as well as the effect on crestal bone loss and prosthesis success and maintenance outcomes, are not addressed in detail in this paper. As most commonly reported in implant outcome studies, implant survival and success were assessed from the time of implant placement rather than from prosthesis loading. Finally, despite being arguably the most crucial outcomes for clinical decisions, no data are given on functional or psychosocial outcomes, eg, patient satisfaction, quality of life, and economic analysis. Further publications will be required to analyze these various aspects.

MATERIALS AND METHODS

Initial Search Strategy

A broad PubMed search was undertaken on August 23, 2004 to identify study references by title, with the abstract when available, reporting the outcome of dental implant treatment. The terms "(dental implants OR dental implant OR dental implantation) AND (evaluation studies OR epidemiologic methods OR health care evaluation mechanisms)" were utilized to conduct the initial search which was limited to studies published in English and conducted with humans. This search resulted in 3,189 references (Fig 1). Initial inclusion and exclusion criteria were applied independently by 2 reviewers; 1,766 title/abstract references for studies were included. Studies were included if they had more than 1 subject with any of the oral implant outcomes described by Gukes and Shugars,[79] such as implant survival or success longevity according to Albrektsson and colleagues[80] or Zarb and Albrektsson,[81] crestal bone levels or loss, adverse outcomes, prosthesis success or maintenance, function (chewing, speaking, etc), nutritional adequacy, patient satisfaction, appearance, or quality of life. Reviews of implant outcomes studies were included. Papers were included if there was inadequate information to determine exclusion. References for studies describing a single subject or study periods less than 1 year after implant placement were excluded. Disagreements between reviewers were resolved either by reaching consensus or by including the reference for subsequent review by the 8 individual review teams.

Final Inclusion and Exclusion Criteria

The same PubMed search strategy was last repeated on March 8, 2006 to identify 509 additional title/abstract references limited to studies published in English, using human subjects, and published no later than December 31, 2005 (Fig 1). Among the 2,275 references remaining (1,766 plus 509), inclusion and exclusion criteria (Table 1) were applied independently by 2 reviewers (RB and DM) to include 278 references for subsequent full-text review. Included references described implant survival and/or success longevity, crestal bone levels or loss, or prosthesis success or maintenance outcomes specified by prosthesis type in the edentulous arch, including RCTs with follow-up periods of at least 1 year since implant placement or consecutively treated arches in prospective or retrospective cohort studies with follow-up periods of at least 5 years, including those studies with 5-year cumulative implant survival or success data, even if their minimum follow-up periods were less than 5 years (Table 1). Systematic reviews of prosthesis-type outcome studies for the edentulous arch were also included, as well as references for which there was inadequate information to determine exclusion. Disagreements between reviewers on inclusion and exclusion of references were recorded and resolved either by reaching consensus or by including the reference for subsequent full-text review.

A full-text review of the 278 references was conducted independently by the same 2 reviewers, who reapplied the inclusion and exclusion criteria plus 4 additional exclusion criteria (Table 1). Sixty-one studies were included for data extraction, and 217 studies were excluded. The 4 additional criteria excluded prospective or retrospective cohort studies with 5-year cumulative implant survival or success data but minimum follow-up periods of less than 5 years since implant placement, and studies with samples reporting mixed maxillary and mandibular prosthetic sites, mixed fixed and removable prosthesis types, or mixed splinted and nonsplinted prosthesis types.

Recent issues of relevant journals, with a focus on *International Journal of Oral and Maxillofacial Implants, International Journal of Prosthodontics, Clinical Oral Implants Research, Clinical Implant Dentistry and Related Research, Journal of Dental Research, British Dental Journal, Journal of Prosthetic Dentistry, International Journal of Oral Maxillofacial Surgery, Journal of Oral and Maxillofacial Surgery, Journal of Oral Rehabilitation, Journal of Prosthodontics, Journal of Clinical Periodontology,* and *Journal of Periodontology*; a personal library of implant outcomes literature; and reference lists from all included papers were hand-searched to identify a total additional 81 title/abstract references, yielding an overall total of 2,356 references remaining for review (Fig 1). These were reviewed, and the final inclusion and exclusion criteria (Table 1) were applied independently by the 2 reviewers to include a total additional 55 references for full-text review, yielding an overall total of 333 full-text studies for review, and an overall total of 2,023 studies excluded at the title/abstract stage. Disagreements between reviewers on inclusion and exclusion of references were recorded and resolved either by reaching consensus or by including the reference for subsequent full-text review. A full-text review of the 55 additional included references was conducted independently by the reviewers using the same criteria to include a total additional 11 studies, yielding an overall total of 72 studies[1–72] included for data extraction (Tables 2 and 3). In the process, no

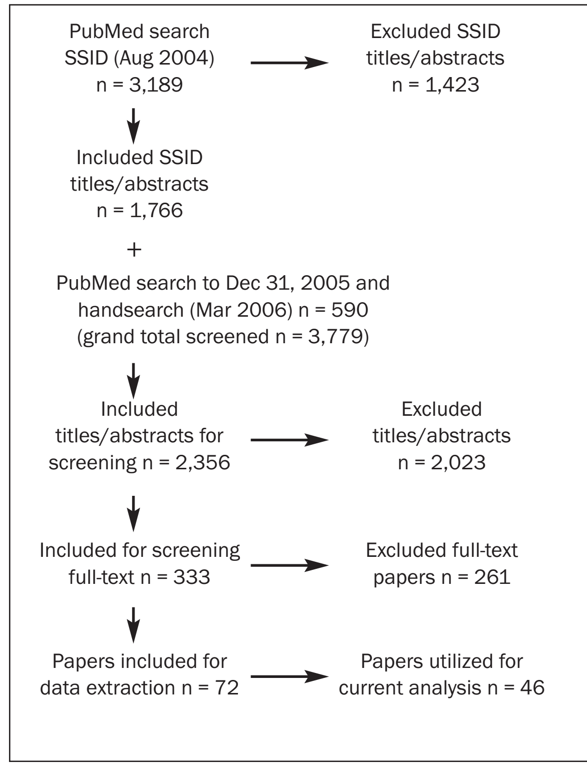

Fig 1 Search process.

Table 1 Final Inclusion and Exclusion Criteria

Inclusion criteria	
	1-year RCT with outcomes* by prosthesis type in completely edentulous arch
	5-year observational study of outcomes* in completely edentulous arch
	Systematic review of outcomes by prosthesis type in completely edentulous arch
Original exclusion criteria	
P	Partially edentulous arch
L	Length of study < 60 mo from implant placement for observational studies
LR	Length of study < 12 mo from implant placement for RCT
CR	Case report with < 5 arches per group
I	Implant placed immediately postextraction (< 10 wk) or loaded immediately (< 10 wk from placement)
G	Graft/augmentation
NC	Nonconsecutive sample (eg, sample selection based on failure, success, mucosal inflammation, or case-control) or special-risk sample (eg, systemic illness, medication use, smoking habits, irradiation, or chemotherapy)
NH	No in vivo human outcomes
NT	Nontitanium (Ti alloy) root-form implant (eg, blade, transmandibular, ceramic)
Z	Extramaxillary site (eg, zygoma, pterygoid plate)
OO	Other outcomes (eg, occlusal, function, satisfaction, economic analyses)
OS	Other systematic review
R	Review, editorial, or protocol paper (or no implant outcomes)
Additional exclusion criteria	
LB	Maximum length of observation was < 60 mo for some patients in observational studies despite cumulative survival or success rates > 60 mo
M	Maxillary and mandibular mixed sample
F	Fixed and removable mixed sample
S	Splint/no splint mixed sample

*Outcomes: oral implant survival or success,[80,81] crestal bone level or loss, prosthetic success, or prosthetic maintenance.

systematic reviews were identified that directly examined the PICO (problem, intervention, comparison, and outcome) question. A majority of the exclusions at the full-text review stage were due to groups with pure or mixed partially edentulous arches and/or an inadequate length of follow-up (Table 4). The list of 261 excluded full-text papers, including reasons for exclusion, is available in the Web edition of this paper. Cases of disagreement between reviewers on inclusion and exclusion of full-text papers were recorded and resolved by reaching consensus.

Interreviewer Agreement

For the 2,356 titles and abstracts reviewed specifically for this section, the reviewers had 259 disagreements (11%) in applying inclusion and exclusion criteria. Agreement at the title/abstract review stage yielded a kappa score of 0.61 (moderate to substantial agreement), which was significantly different from zero ($P < .001$), meaning the agreement was better than chance. For the 333 full-text papers reviewed, the reviewers had 53 (16%) disagreements in applying inclusion and exclusion criteria. Agreement at the full-text review stage yielded a kappa score of 0.58 (moderate to substantial agreement), which was also significantly different from zero ($P < .001$).

Data Extraction

Data extraction was completed by 1 reviewer (RB) for each of the 72 included papers using a standardized electronic spreadsheet to manually record data by prosthesis type for each known timepoint or interval. Data extracted included raw or cumulative implant survival and success longevity, crestal bone levels and/or loss, raw or cumulative prosthesis success (by each paper's definition), and prosthesis maintenance outcomes (events, visits, occasions, and/or time). Among the included studies, 45 studies reported apparently unique (ie, not included in another paper) implant survival data (ie, implant present or immobile and retaining a prosthesis) differentiated by prosthesis type. Three studies reported unique implant success data (ie, peri-implant area also free of pathology and radiolucency, with minimal crestal bone loss, in the spirit of Albrektsson and colleagues[80]), 2 of which were among the 45 studies with unique survival data. Republication of implant survival data (ie, not unique) was found in 14 other papers (Table 3), and the remaining 12 papers (Table 3) contained no implant survival or success data, leaving 46 papers utilized for the current analysis (Table 2, Fig 1). A sample of 12 papers (20% selected randomly from the 46 utilized papers, and all 3 papers with success data) were chosen for data

Table 2 Included Papers by Prosthetic Type and Author

Design	Author	Year	Type of prosthesis	No. of groups	No. of implants	Mo. follow-up
PS	De Bruyn et al[11]	1999	MxF	1	35	90
RS	Ivanoff et al[24]	2000	MxF	1	218	180
RCT	Jemt et al[27]	2002	MxF (gold vs titanium frame)	2	349	60
PS-B	Adell et al[3]	1981	MxF vs MnF (some overlap with Adell et al[2])	4	1,322	120
PS-B	Adell[1]	1983	MxF vs MnF (some overlap with Adell et al[2])	4	1,017+r	72
PS-B	Adell et al[2]	1990	MxF vs MnF	6	2,651	180
RS-W	Brånemark et al[7]	1995	MxF vs MnF and 4 vs 6 implants	4	122	120
PS-B	Carlsson et al[8]	2000	MxF vs MnF	2	354	180
RS-B	Engfors et al[63]	2004	MxF vs MnF	4	1,431	60
RS-B	Hultin et al[23]	2000	MxF vs MnF	2	505	60
RCT	Ortorp and Jemt[61]	2004	MxF vs MnF and gold vs titanium frame	4	361	60
PS-B	Rasmusson et al[50]	2005	MxF vs MnF	2	199	120
PS	Arvidson et al[4]	1998	MnF	1	618	60
PS	Ekelund et al[15]	2003	MnF (some overlap with Carlsson et al[8])	1	273	240
PS	Ericsson et al[17]	1997	MnF	1	63	60
PS	Hemmings et al[20]	1994	MnF	1	130	60
PS	Henry et al[21]	1995	MnF	1	83	120
PS	Jeffcoat et al[25]	2003	MnF	1	615	60
PS	Lindquist et al[31]	1988	MnF (some overlap with Carlsson et al[8])	1	152	72
PS-W	Murphy et al[37]	2002	MnF gold versus silver palladium frame	2	131	60
RS-W	Ortorp et al[40]	1999	MnF gold vs titanium or titanium bar frame	3	1,034	60
RCT	Tinsley et al[42]	2001	MnF vs removable ball with 5 or 3 implants	2	181	72
PS-W	Makkonen et al[32]	1997	MnF vs bar with 6 or 4 implants	2	155	60
PS-W	Watson and Davis[49]	1996	MnF vs bar with 6 or 2 implants	2	170	60
RS-W	Jemt and Lekholm[28]	1995	MxR bar vs bar-then-F vs F; 4 vs 6 implants	3	38	60
PS-B	Jemt et al[64]	1996	MxR bar vs Mn; 4 vs 2 implants	2	393	60
PS	Smedberg et al[41]	1999	MxR Nonrotat with 5 implants	1	86	60
PS	Cordioli et al[9]	1997	MnR ball with 1 implant	1	21	60
PS	Deporter et al[12]	1999	MnR with 3 implants (some overlap with Deporter et al [13])	1	156	72
PS	Deporter et al[13]	2002	MnR with 3 implants	1	156	120
PS	Heckmann et al[53]	2004	MnR telescopic nonrotat with 2 implants	1	82	96
PS	Walmsley and Frame[44]	1997	MnR magnet rotat with 4 implants	1	78	60
RCT	Davis and Packer[10]	1999	MnR magnet vs ball; 3 vs 2 implants	2	99	60
RCT	Gotfredsen and Holm[18]	2000	MnR unsplinted vs splinted; ball vs bar	2	52	60
RCT	Naert et al[39]	1997	MnR unsplinted vs splinted; magnet vs ball; some overlap with Naert et al[55]	3	72	36
RCT	Naert et al[55]	2004	MnR unsplinted vs splinted; magnet vs ball	3	72+1r	120
RCT	Wismeijer et al[48]	1999	MnR unsplinted vs splinted; ball vs bar; 2 vs 4 implants	3	283	16
RCT	Visser et al[57]	2005	MnR bar rotat vs nonrotat; 2 vs 4 implants	2	120	60
PS	Behneke et al[6]	2002	MnR bar with 2 to 5 implants	1	337	60
PS	Meijer et al[33]	2004	MnR bar rotat with 2 implants	3	180	60
PS	Meijer et al[34]	2001	MnR bar rotat with 2 implants	2	116	60
PS	Meijer et al[35]	2003	MnR bar rotat with 2 implants	1	122	120
PS	Meijer et al[59]	2004	MnR bar rotat with 2 implants	1	122	120
PS	Visser et al[43]	2002	MnR bar rotat with 2 implants	3	180	60
PS	Wismeyer et al[65]	1995	MnR bar mix rotat with 2 implants	1	218	66
RS	Heydenrijk et al[22]	1998	MnR bar rotat with 2 implants	1	86	65

F = fixed; B = between-arch comparison; ball = ball-retained; bar = bar-retained; Mx = maxillary; Mn = mandibular; PS = prospective study; R = removable; r = replacement implant(s); RCT = randomized controlled trial; rotat = rotational type; RS = retrospective study; W = within-arch comparison.

extraction by the second reviewer (DM). No errors were detected in comparison to the original data extraction.

Data Analysis

The current analysis was intended for pooling percentages of implant survival, implant success, and prosthesis success. The parameters given for prosthesis success were very inconsistent across studies, varying from continuous prosthesis stability to a set maximum number of prosthetic maintenance visits or events, so only implant survival and success were pooled in the current analysis. These data were assumed to be cumulative even if they were given as an absolute or raw proportion of the original number of implants reported. This assumption was consid-

Table 3 Included Unused Papers by Exclusion Reason, Design, and Author

Design	Author	Year	Exclusion reason and type of prosthesis	No. of groups	No. of implants	Mo. follow-up
RCT	Batenburg et al[5]	1998	Survival data overlap with Visser et al[57]	2	180	12
RCT	Davis et al[56]	1996	Survival data overlap with Davis and Packer[10]	2	100	36
RCT	Gotfredsen[67]	1997	Survival data overlap with Gotfredsen and Holm[18]	2	40	48
RCT	Jemt et al[69]	1998	Survival data overlap with Jemt et al[27]	2	349	24
RCT	Naert et al[38]	1999	Survival data overlap with Naert et al[55]	3	72	60
RCT	Ortorp and Jemt[51]	2002	Survival data overlap with Ortorp and Jemt[61]	4	361	36
RCT	Ortorp and Jemt[52]	2000	Survival data overlap with Ortorp and Jemt[61]	4	361	12
PS	Ericsson et al[16]	2000	Survival data overlap with Ericsson et al[17]	1	30	60
PS	Jemt[26]	1994	Survival data overlap with Jemt and Lekholm[28]	1	449	60
PS	Lindquist et al[29]	1987	Survival data overlap with Carlsson et al[8]	1	148 (2 pts lost)	60
PS	Lindquist et al[30]	1996	Survival data overlap with Carlsson et al[8]	2	273	180
PS	Lindquist et al[68]	1997	Survival data overlap with Carlsson et al[8]	1	266	120
PS	Meijer et al[70]	1999	Survival data overlap with Meijer et al[35]	1	122	60
PS	Meijer et al[36]	2000	Survival data overlap with Meijer et al[59]	2	122	60
RCT	MacEntee et al[54]	2005	No survival data; MnR ball vs bar; unsplinted vs splinted with 2 implants	2	200	36
RCT	Naert et al[60]	2004	No survival data; MnR splinted vs unsplinted; bar vs magnet vs ball	3	72 +1r	120
RCT	Naert et al[66]	1998	No survival data; MnR splinted vs unsplinted; bar vs magnet vs ball	3	72	60
RCT	Payne and Solomons[72]	2000	No survival data; MnR ball vs bar; splinted vs unsplinted; rotat vs nonrotat; 2 vs 4 implants	3	149	36
RCT	Walton et al[45]	2002	No survival data; MnR ball vs bar; splinted with 2 implants vs unsplinted	2	134	12
RCT	Walton and MacEntee[62]	2003	No survival data; MnR ball vs bar; splinted with 2 implants vs unsplinted	2	200	24
RCT	Watson et al[46]	2002	No survival data; MnR; 4 attachment types; nonrotat vs rotat with 2 implants	4	144	12
RCT	Watson et al[47]	2002	No survival data; 4 attachment types; nonrotat vs rotat with 2 implants	4	144	12
PS-B	Astrand et al[58]	2004	No survival data; MxF vs MnF	4	371	60
PS-W	Hellem et al[19]	2001	No survival data; MnR bar vs F with 4 or 6 implants	2	216	60
PS-B	Watson et al[71]	1997	No survival data; MnR bar vs Mx; rotat vs mix rotat; 2 vs 4 implants	2	393	60
PS	Dudic and Mericske-Stern[14]	2002	No survival data; MnR bar; nonrotat; 4 implants	1	258 (34 pts lost)	180

F = fixed; B = between-arch comparison; ball = ball-retained; bar = bar-retained; Mx = maxillary; Mn = mandibular; PS = prospective study; pts = patients; r = replacement implant(s); R = removable; RCT = randomized controlled trial; rotat = rotational type; W = within-arch comparison.

ered reasonable for the current analysis, since only studies with minimum follow-up periods of 5 years were used for the graphic plots and meta-analyses reported. Raw data from individual studies were used where possible to compute the appropriate cumulative survival and/or success rate for use in the analysis based on a traditional life-table approach utilizing the conditional probability of implant survival or success at the midpoint of each interval.

For the purposes of descriptive summaries, timepoint analyses were made for examination data collected at loading and at 12, 36, 48, 60, 120, and 180 months after loading, whereas overall analyses were made at the last reported examination if it was at least 48 months after loading. A 6-month window was used to categorize examinations by timepoint, except for the initial 6-month period. In this way examinations after load were grouped into the following periods: 12 to 18 months, 36 to 42 months, 48 to 54 months, etc. If the data did not fall into one of these ranges, then it was not included in the analysis by timepoint.

Two types of formal analysis were intended to aggregate the data. First, implant and prosthesis survival and success data were to be summarized descriptively by timepoint both numerically and graphically for all studies according to prosthesis type. This yielded both pooled numerical estimates with 95% confidence intervals (CIs) at each timepoint and graphic plots at each timepoint of the outcome of included studies and the pooled estimate, all with 95% CIs.

Table 4 Frequency of Reasons for Excluding Full-text Studies (n = 261*)

Code	Reason for exclusion	No. of studies
P	Partially edentulous arch or ambiguous	99
L	Observational study with < 60 mo follow-up from implant placement	45
LR	< 12 mo from implant placement for RCT	6
LB	< 60 mo for observational study minimum despite CSR ≥ 60 mo	28
CR	Case report < 5 arches per group	5
I	Immediate implant placement (< 10 wk postextraction) or loading (< 10 wk from placement)	4
G	Graft, augmentation	8
M	Maxillary and mandibular mixed sample	16
F	Fixed and removable mixed sample	8
S	Splint and unsplinted mixed sample	8
NC	Nonconsecutive or special risk samples (eg, failure, case control, illness, irradiation, smoking)	9
NH	No in vivo human outcomes	4
NT	Nontitanium (titanium alloy) root-form implant (eg, blade, transmandibular, ceramic)	11
Z	Extramaxillary site (eg, zygoma, pterygoid plate)	0
OO	Other outcomes (eg, occlusal, function, satisfaction, economic analyses)	15
OS	Other systematic review for a different question	1
R	Review, editorial, protocol paper (no implant outcomes)	26
RP	Republished paper	2

*Some studies excluded for more than 1 reason; thus, the total exceeds 261.

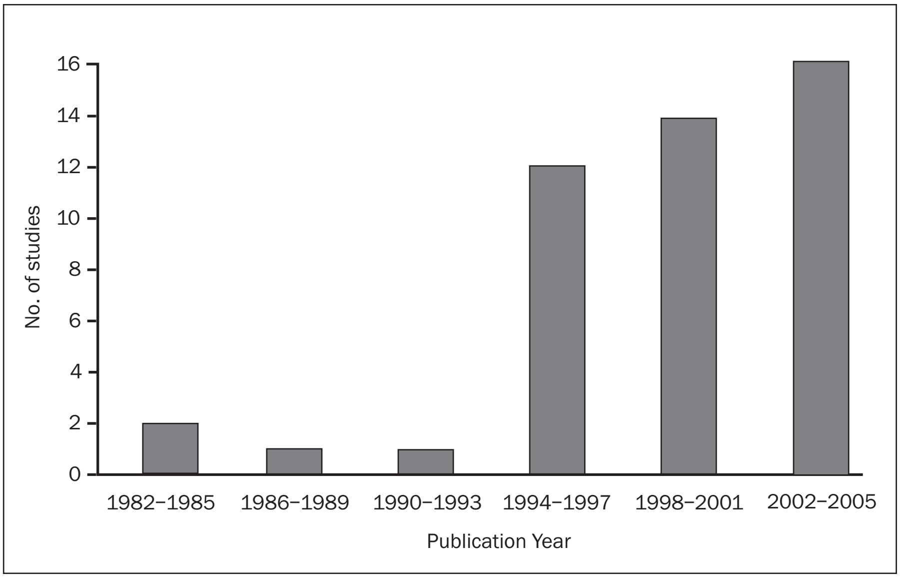

Fig 2 Number of included, utilized papers by publication year.

Second, where possible, meta-analysis statistical testing involved a z-test of the weighted mean risk difference in the overall survival or success rates comparing 2 prosthesis types with weighting based on the number of implants in studies reporting 2 or more types. A hypothesis test for the difference between 2 treatments could not be performed unless the individual studies contained both treatments. The test was only performed overall, that is, at the last reported examination, if it was at least 48 months after loading because of the small number of papers containing both treatments at a particular time. If less than 2 studies contained both treatment groups, then this analysis was not performed.

RESULTS

Design of Included Studies

Of the 46 studies utilized in the current analysis (Table 2), very few were published prior to 1994, and approximately one third were published after 2001 (Fig 2). Fifteen studies involved more than 1 prosthesis type within the maxillary and mandibular arches, allowing prosthesis-type comparison within arches. Of these, 9 were RCTs or quasi-RCTs, 3 were prospective studies (PS-W), and 3 were retrospective studies (RS-W). Eight studies involved both arches but had only 1 prosthesis type in each arch; these studies allowed comparison only between arches. Of these 8

Table 5 Descriptive Outcomes by Prosthesis in All Included Studies (n = 72)

	Prosthesis type									
	Maxillary fixed		Mandibular fixed		Maxillary removable splinted		Mandibular removable splinted		Mandibular removable nonsplinted	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
% implant survival overall—at least 60-mo data	74.2	97.0	86.0	100.0	71.3	83.7	83.0	100.0	86.0	100.0
First year bone loss (mm)	0.02	0.55	0.09	0.80	0.20	0.50	−0.20	1.17	−0.40	0.90
Annual bone loss (mm/y) after 12 mo	0.00	0.20	-0.14	0.13	0.08	0.13	−0.01	0.23	−0.07	0.38
% continuous prosthesis stability overall—less than 60-mo data	96.8	100.0	100.00		–	–	100.0		100.0	
% continuous prosthesis stability overall—at least 60-mo data	88.0	100.0	99.0	100.0	77.9	86.7	100.0		100.0	
% original prosthesis failures or remakes overall—less than 60-mo data	7.1	19.4	0.0	23.8	–	–	–	–	0.0	63.0
% original prosthesis failures or remakes overall—at least 60-mo data	1.3	22.6	0.0	44.0	45.5	72.0	0.0	36.4	0.0	16.7
% no major prosthesis modifications overall—less than 60-mo data	–	–	–	–	–	–	63.0		23.0	
Prosthetic implant component maintenance events, visits, or occasions per prosthesis per 60 mo	0.0	0.1	0.0	1.2	1.0	5.9	0.1	4.6	0.0	16.5
Total prosthetic maintenance events, visits, or occasions per prosthesis per 60 mo	0.4	14.3	0.1	11.4	2.9	24.6	0.6	15.4	0.0	19.4

studies, 6 were prospective studies (PS-B) and 2 were retrospective studies (RS-B). The remaining 23 studies had only 1 prosthesis type in 1 arch (ie, no possible prosthesis type comparison was possible). Of these, 21 were prospective studies (PS), including RCTs not comparing prosthesis type, and 2 were retrospective studies (RS). Among the 46 utilized studies, 6 studies[1,3,12,15,31,39] gave outcomes data for the same subjects found in 4 other utilized studies,[2,8,13,55] but included data at unique timepoints. In other words, the 46 papers involved only 40 distinct study samples. A concerted effort was made to eliminate all overlapping data from the analysis.

Descriptive Outcomes

Fixed and removable prosthetic designs were found to have clinically similar levels of overall implant survival, ranging from 71.3% to 97.0% in the maxilla and from 83.0% to 100.0% in the mandible (Table 5), not including the developmental groups reported in the original Adell studies.[1–3] Likewise, similar levels of crestal bone loss were reported during and after the first year of prosthetic function, up to 0.55 mm in the first year and up to 0.2 mm per year thereafter for maxillary fixed and removable prostheses and up to 1.17 mm in the first year and up to 0.38 mm per year thereafter for mandibular fixed and removable prostheses (Table 5).

In contrast, the percentage of prosthetic success ranged widely across studies and prosthetic types. Measures included variations of percentage of continuous prosthesis stability, percentage of original prosthesis failures or remakes, and percentage of prostheses with no major modification. Measures of continuous prosthesis stability yielded high proportions of success, generally exceeding 75%, whereas the latter 2 measures yielded highly variable but potentially more sensitive measures of success, or failure, with results ranging from the equivalent of 23% to 100% success (Table 5). The data reported for prosthetic maintenance appeared to be inconsistently assessed and reported across studies. Variable definitions of events, visits, and occasions were used, with or without accounting for prosthetic maintenance conducted at routine reassessment visits. A potential consequence was that even within 1 prosthesis type, the rate of prosthetic maintenance events, visits, or occasions appeared to vary from 0 to more than 20 units per prosthesis over a 60-month period (Table 5). From this information it appears most reasonable to expect that substantial prosthetic maintenance requirements should be anticipated for implant-supported prostheses in the edentulous arch. Furthermore, among the few RCTs assessing prosthetic maintenance for removable overdenture designs, there was evidence that variation in prosthetic maintenance can be due to variation in prosthetic design, in particular the design of the attachment mechanism.[10,46,60,62] Detailed analysis of the type and extent of prosthetic maintenance was not performed.

Although both fixed and removable prosthesis designs were reported in maxillae and mandibles across the included studies, a maxillary removable design was found in only 3[28,41,64] of the 46 studies, none of which were RCTs (Table 2). Maxillary removable prostheses generally involved a splinted and nonrotational design—a bar overdenture—with a maximum of 4 to 6 implants. Maxillary and mandibular removable overdentures were usually fabricated with acrylic resin prosthetic teeth processed on a rigid acrylic resin base that was reinforced with a metal frame often in the maxilla but only occasionally in the mandible. Likewise, all of the fixed prostheses reported in the included papers were of a splinted, nonrotational design, most often with acrylic resin prosthetic teeth processed on a rigid metal frame. Several papers reported clinically consistent results using various metal framework materials for fixed maxillary and mandibular prostheses, for example, cast gold or silver-palladium alloys, and different forms of milled and/or welded titanium frames. Exclusively metal-ceramic fixed designs have occasionally been reported in the literature; however, no studies involving groups using only metal-ceramic materials met the criteria for inclusion in the present study. The fixed prosthesis frames were typically screw-retained rather than cemented designs, as were the removable prosthesis attachment anchors and bars.

Only 1 study[7] reported fixed prostheses supported by less than 5 implants. This study was a 10-year retrospective study with both maxillary and mandibular complete fixed prostheses supported by either 4 or 6 implants. No clinically important difference in implant survival was observed between the 4-implant design (80.3% maxillary jaw survival and 88.4% mandibular jaw survival) and the 6-implant design (79% maxillary survival and 93.2% mandibular survival).

By far the greatest variation in prosthetic design was observed among studies reporting the outcomes of mandibular complete removable (overdenture) prostheses. Both splinted (bar attachment) and nonsplinted (often ball or magnet attachment) designs were utilized, with no clinically important difference in implant survival (Table 5). Most of the prostheses were supported by 2 implants, but there were also designs with 1, 3, and 4 or more implants; again, no clinically important differences in implant survival were observed. Likewise, both nonrotational and rotational overdenture designs enjoyed clinically similar implant survival. In comparison to rotational overdentures, a nonrotational design implies a more rigid connection between the prosthesis and implant such that the overdenture could transmit a substantial torque force to the attachment mechanism and implants during function. Perhaps for this reason, the nonrotational overdenture designs[6,32,48,53,57,64,65] tended to be planned with 3 or more implants, presumably to increase the interfacial support to resist rotational torque on the implants under occlusal loading and to provide increased prosthetic stability. Of note, the nonrotational designs were not exclusively bar overdentures[42,53,64] with more than 2 implants. Nonetheless, implant survival did not appear to vary by splinting, rotational characteristics, or number of implants. Indeed, 1 study[9] reported 100% implant survival in a 5-year prospective study of rotational mandibular overdentures supported by a single midline implant. Detailed analysis of the effect of splinting and rotational features and of implant number was not undertaken in the current review.

Implant Survival by Prosthesis Type

A maxillary removable design was reported in only 3[28,41,64] studies with a pooled implant survival estimate of 76.6% at 5 years (Fig 3). In comparison, the

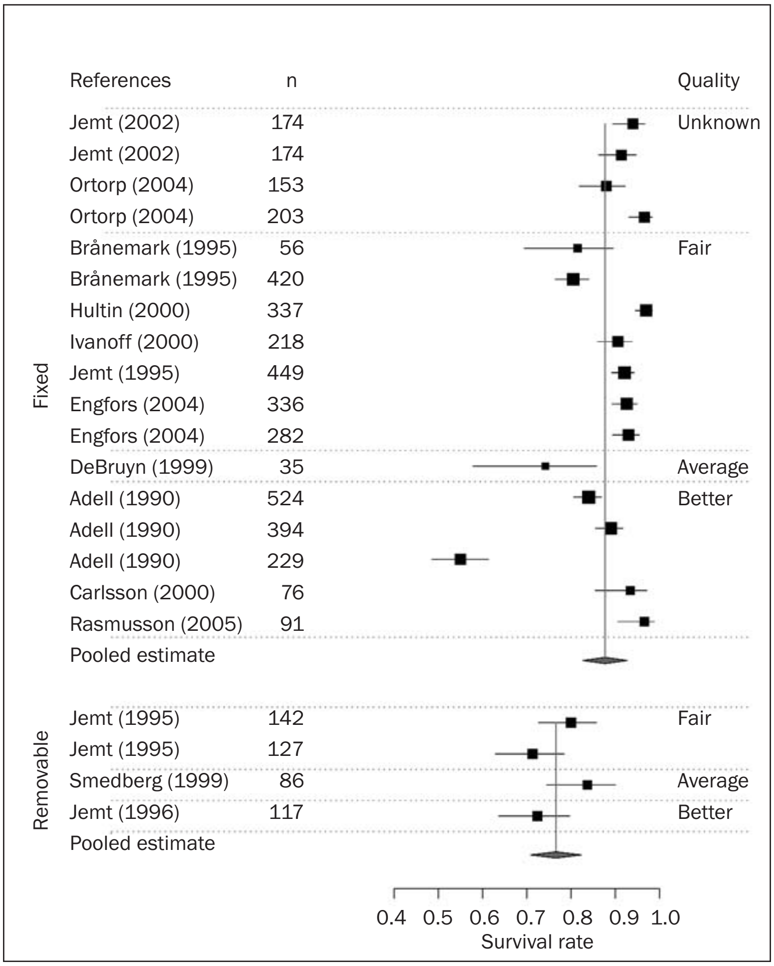

Fig 3 Pooled implant survival—Maxillary fixed and removable prostheses at 60 months.

maxillary fixed design was reported in 11 studies with a pooled implant survival estimate of 87.7% at 5 years (Fig 3), and the mandibular removable and fixed designs were reported in at least 15 studies each (Fig 4), with pooled implant survival estimates of 95.7% and 96.7%, respectively, at 5 years. Only 10 of the included papers reported implant survival results at or beyond 10 years, none of which reported a maxillary removable design. A maxillary fixed design was reported in 5 studies[2,7,8,24,50] at 10 years (including the developmental group in Adell and associates[2]), with a pooled implant survival estimate of 80.7% (Fig 5). This design was reported in only 2 studies[2,24] at 15 years (also including the developmental group reported by Adell and associates[2]), with a pooled implant survival estimate of 70.3% (Fig 6). A mandibular removable design was reported in 4 studies[13,35,55,59] at 10 years, with a pooled implant survival estimate of 95.4% (Fig 7). A mandibular fixed design was reported in 5 studies[2,7,8,21,50] at 10 years (again including the developmental group reported by Adell and associates[2]), with a pooled implant survival estimate of 91.0% (Fig 7). This design was reported in only 2 studies[2,8] at 15 years (also including the developmental group reported by Adell and associates[2]), with a pooled implant survival estimate of 82.2% (Fig 8).

All told, the only suggestion of a possible difference in implant survival purely by prosthetic design was found in the lack of overlap in 95% CIs for the descriptive aggregate analysis by timepoint for maxillary fixed and removable prosthesis types (Fig 3). The 95% CI of survival at 60 months for groups with the maxillary fixed design was 82.7% to 92.7%, compared with 70.9% to 82.3% for groups with the maxillary removable design. The 48-month timepoint analysis revealed similar results. Although this lack of overlap between the CIs is suggestive of differences in the pooled estimates, no hypothesis testing was possible with these pooled estimates because the differences did not arise within more than 1 controlled study.

Four papers reported both fixed and removable prostheses groups in the same study; 3 involved the mandible[32,42,49] and 1 involved the maxilla.[28] All 4

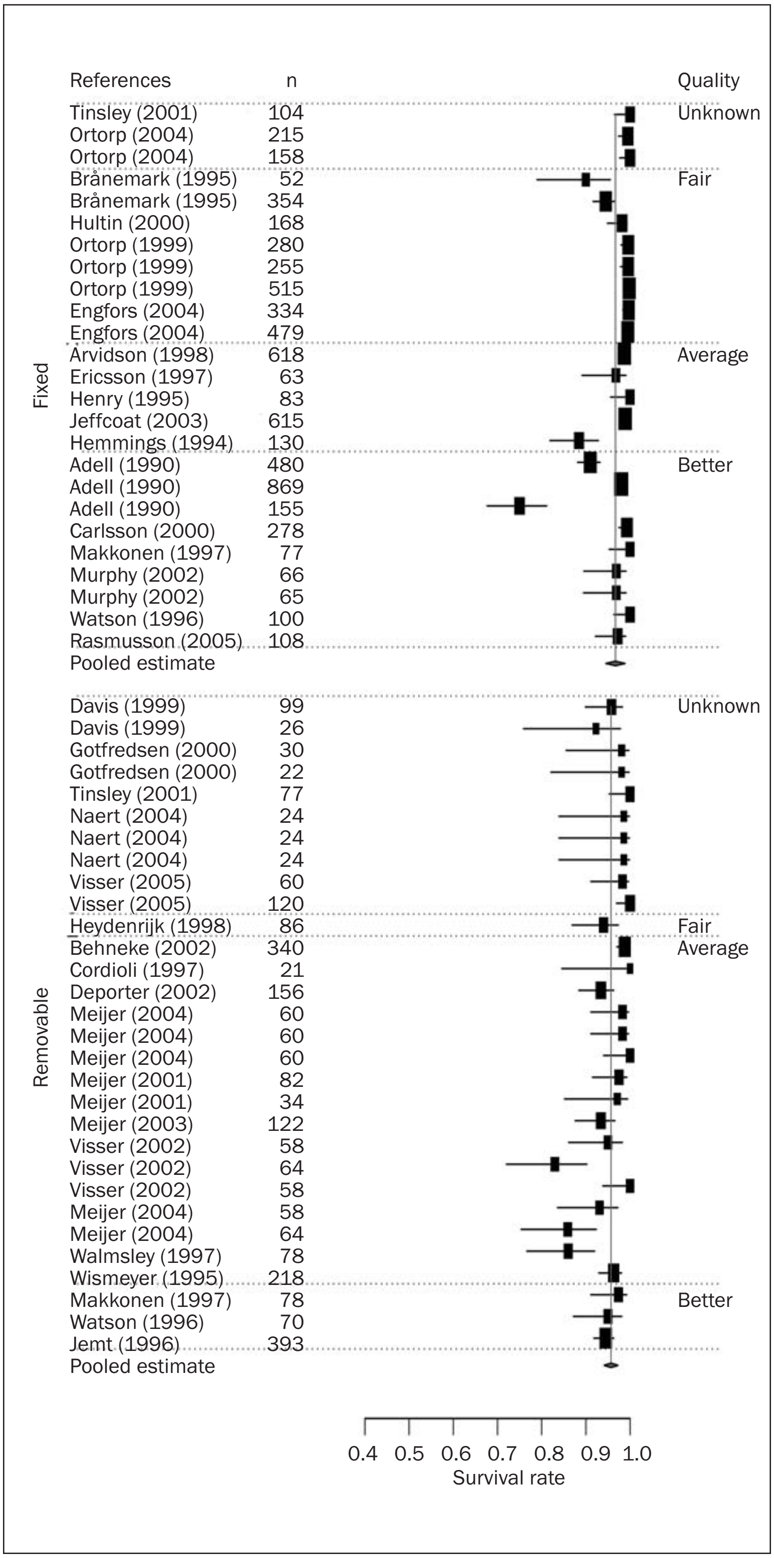

Fig 4 Pooled implant survival—Mandibular fixed and removable prostheses at 60 months.

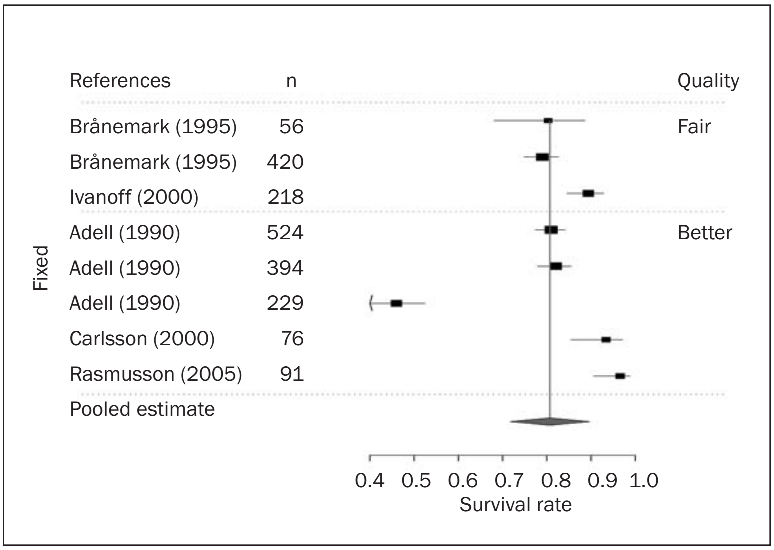

Fig 5 Pooled implant survival—Maxillary fixed prostheses at 120 months.

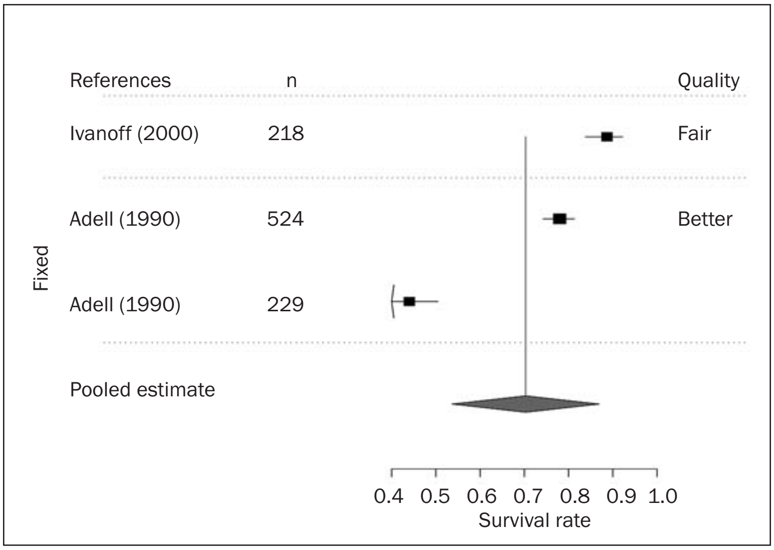

Fig 6 Pooled implant survival—Maxillary fixed prostheses at 180 months.

studies had the same amount of follow-up (60 months from loading). Those involving the mandible reported implant survival of 100% in the 3 fixed prosthesis groups at 60 months, and ranged from 95% to 100% in the 3 removable prosthesis groups. Although no clinically important differences could be observed between these implant survival rates, statistical testing was possible to test formally for differences in the pooled estimates between the mandibular fixed and removable designs, and this is reported in the meta-analyses section.

In contrast, the lone maxillary study[28] with both fixed and removable groups did seem to suggest a clinically important difference across the groups. Three groups were reported including a severe resorption removable bar-overdenture group with 3 or 4 implants (76% of which were 7 mm in length, with the balance at least 10 mm), an intermediate group planned initially for a removable bar-overdenture with 5 or 6 implants (64% of which were 7 mm in length, with the balance at least 10 mm) and intended for subsequent conversion to a fixed prosthesis after at least 1 year, and a fixed prosthesis group with 5 or 6 implants (24% of which were 7 mm in length, with the balance at least 10 mm). The reported cumulative implant failure (assumed for the current analyses to be equivalent to 100% minus the cumulative implant survival) at 60 months was 28.7% in the severe resorption group, 20.0% in the intermediate group, and 7.9% in the fixed prosthesis group. Hypothesis testing was not possible to compare the effect of prosthesis design on implant survival not only because the differences arose from only 1 retrospective study, but also because the 3

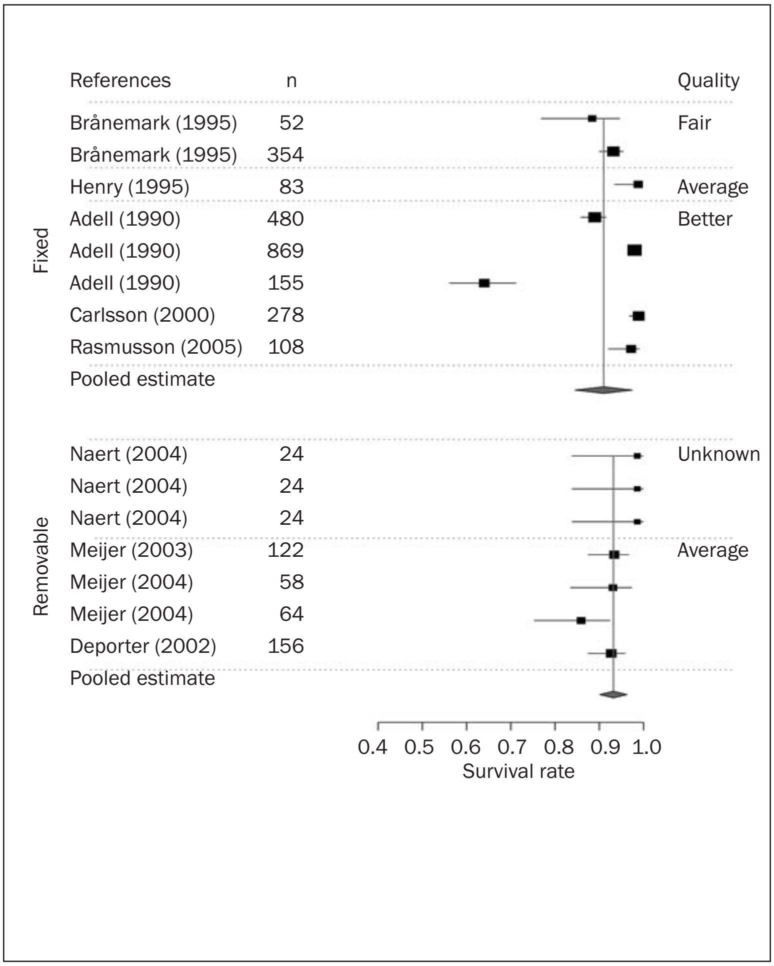

Fig 7 Pooled implant survival—Mandibular fixed and removable prostheses at 120 months.

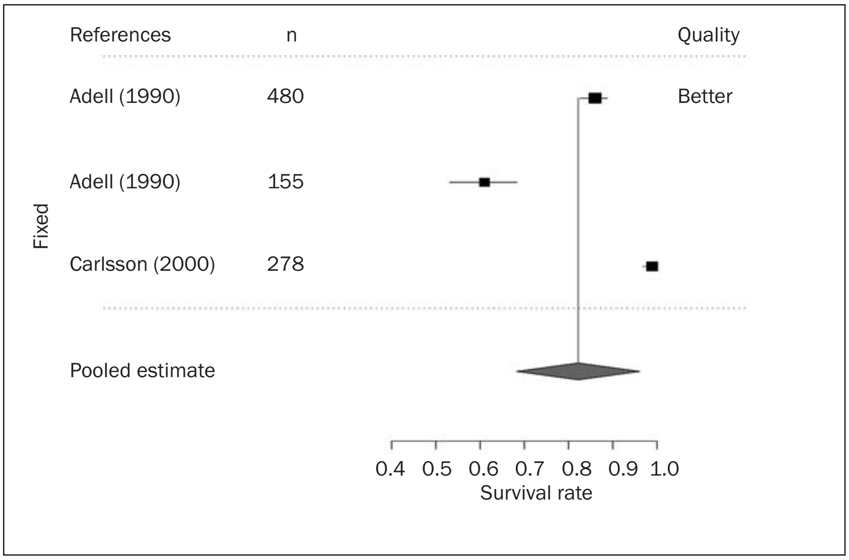

Fig 8 Pooled implant survival—Mandibular fixed prostheses at 180 months.

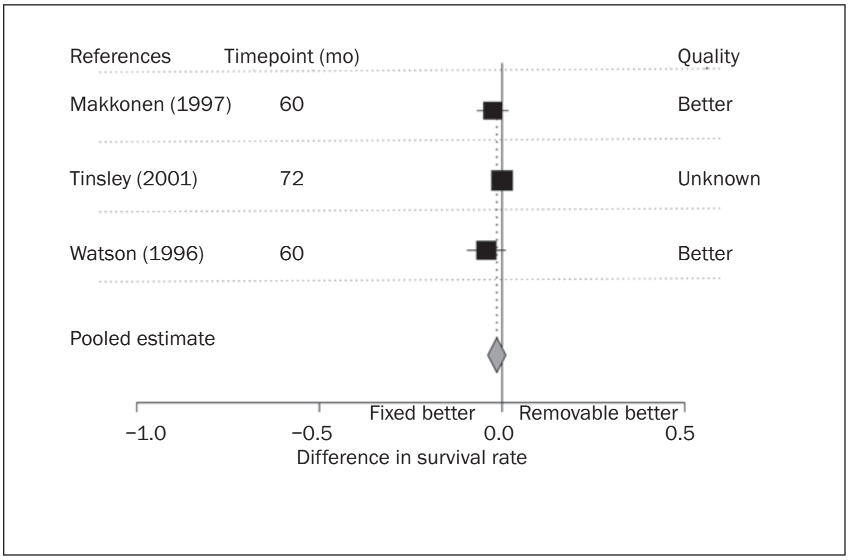

Fig 9 Forest plot of studies comparing mandibular removable and fixed prostheses. No significant difference in estimated risk was found (−1.4%; 95% CI, −3.9% to 1.03%; $P > .05$).

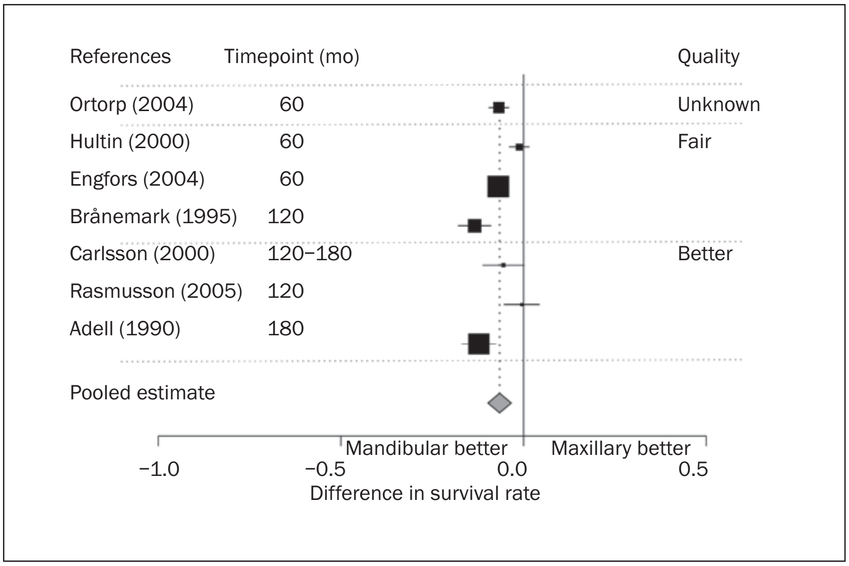

Fig 10 Forest plot of studies comparing maxillary and mandibular fixed prostheses. A significant difference in estimated risk was found (−6.6%; 95% CI, −9.8% to −3.4%; $P < .001$).

groups were selected deliberately according to differences in bone volume that appeared to favor implant survival in the fixed prosthesis group as anticipated.

A possible site-specific difference (rather than purely a prosthetic type difference) was also suggested because of the lack of overlap in 95% CIs for the maxillary and mandibular removable prosthesis types in the 12-, 36-, 48-, and 60-month timepoint analyses of implant survival, and similarly, for the maxillary and mandibular fixed prosthesis types, not including the 12-month timepoint. For example, the 95% CI of survival at 60 months for groups with the maxillary fixed design (Fig 3) did not overlap that of the groups with the mandibular fixed design (CI was 94.5% to 98.9% for the latter group; Fig 4). Likewise, the 95% CI of survival at 60 months for groups with the maxillary removable design (Fig 3) did not overlap that of the groups with the mandibular removable design (CI was 94.1% to 97.3% for the latter group; Fig 4). In this instance, statistical testing was only possible to test formally for differences in the pooled estimates between the fixed maxillary and mandibular designs, and this is reported in the meta-analyses section.

Implant Success by Prosthesis Type

Implant success by prosthesis type was reported in only 3 papers,[6,12,42] all involving mandibular fixed and/or removable prosthesis groups. Implant success was 71% in the only mandibular fixed prosthesis group reported[42] and ranged from 71% to 95.7% in the 3 mandibular removable prosthesis groups.[6,12,42] The only study reporting implant success among both fixed and removable prosthesis groups[42] found identical implant success at 60 months utilizing coated implants. Statistical comparison across papers was not possible because of an inadequate number of studies with both groups and because of likely differences in the application of success criteria.

Meta-Analyses of Implant Survival

The 2 possible meta-analyses with statistical testing for this review involved comparisons of mandibular fixed and removable prostheses reported in the same study and of fixed prostheses in both maxillary and mandibular arches reported in the same study (Table 2). All 3 of the studies with mandibular fixed and removable prostheses[32,42,49] were included in the hypothesis testing. The fixed prostheses were each supported by 5 or 6 implants, whereas the removable prostheses were supported either by 2 implants with bar attachments,[49] 4 implants with bar attachments,[32] or 3 implants with ball attachments.[42] The follow-up periods for these studies varied from 60 to 72 months in duration; only 1 study[42] was randomized. The z-test of the weighted mean risk difference in the overall survival rate comparing mandibular fixed and removable prostheses was not significant at the .05 level ($P > .05$; Fig 9). The estimated risk difference between mandibular fixed and removable prostheses was –1.44% with a 95% CI of –3.9% to 1.03%. This supports the hypothesis that there is no difference in implant survival outcomes comparing fixed and removable prosthesis types in mandibular edentulous arches.

Among the 9 papers[1–3,7,8,23,50,61,63] reporting fixed prostheses in both maxillary and mandibular arches, 2 studies[1,3] had the same subjects found in another[2] of the papers, so only 1 of the 3 studies[2] was included in the hypothesis testing—the study that contained the longest-term overall data for the groups. The follow-up periods varied from 60 to 180 months' duration; 1 study[61] was also a randomized study comparing gold alloy and titanium frame materials. The z-test of the weighted mean risk difference in the overall survival rate comparing maxillary and mandibular fixed prostheses was significant at the .05 level ($P < .001$; Fig 10). The estimated risk difference between maxillary and mandibular fixed prostheses was 6.56%, with a 95% CI of 9.76% to 3.36%. In other words the implant survival rate was 6.6% higher for mandibular fixed prostheses than maxillary fixed prostheses (95% CI: –9.8% to –3.4%, $P < .001$) among established fixed prosthesis designs that have been studied carefully for at least 5 years since loading. At first glance, this result appears to offer a small piece of statistical evidence to refute the hypothesis that there is no difference in implant survival outcomes when comparing fixed and removable prosthesis types in maxillary and mandibular edentulous arches. Of course, this particular statistical comparison did not actually evaluate the outcome of different prosthetic designs within a single arch, as is implied at least clinically in the hypothesis.

The current meta-analyses were limited to comparing fixed and removable prostheses stratified by arch. Subsequent publication by the reviewers is intended to report results according to splinting, rotational freedom, prosthetic attachment, prosthetic materials, opposing dentition, and number of implants.

DISCUSSION

Currently, there is no clear evidence that implant survival or success is affected by prosthesis type based on established designs that have been studied for at least 5 years. However, caution needs to be exercised in not interpreting this to mean that all prosthetic designs can be applied with equal merit and that the results can be applied beyond 5 years. Studies are simply not yet available to guide clinicians sufficiently for many of the possible permutations and combinations of prosthetic design. As an example, studies revealing the merits of ceramometal, cemented, and/or combination fixed-removable designs for the edentulous jaw have not been studied sufficiently for inclusion in the present review, so the current results cannot be assumed to apply equally to all such designs.

That many of the papers available for this review were published after 2001 offers a positive comment on the contemporary state of the science in managing the edentulous state with oral implants. Nonetheless, perhaps not surprisingly, a decade and a half after its publication, Adell et al[2] remains 1 of very few studies reporting implant outcomes beyond 10 years. With the possible exception of removable prosthesis applications for the maxilla, both fixed and removable prosthesis designs enjoyed a clinically high level of implant survival in both maxillary and mandibular arches across the studies included in the review. Among the numerous included papers reporting mandibular fixed and/or removable designs, the pooled implant survival estimates were 97% and 96%, respectively, at 5 years and 91% and 95%, respectively, at 10 years. Only 2 included studies to report a mandibular fixed design at 15 years showed a pooled estimate of 82%. Slightly fewer included papers reported maxillary fixed designs, with a pooled implant survival estimate of 88% at 5 years and 81% at 10 years. The only 2 included studies to report a maxillary fixed design at 15 years showed a pooled estimate of 70%. Only 3 included papers reported on maxillary removable prostheses at 5 years, with a pooled implant survival estimate of 77% among patients often apparently given a removable rather than a fixed prosthesis because of lack of bone volume. No included studies reported on maxillary removable designs at or beyond 10 years or on mandibular removable designs beyond 10 years.

Another substantive result of this review is the finding of a rather complicated range of prosthetic success and maintenance outcomes reported across studies (eg, continuous prosthesis stability, original prosthesis failures or remakes, and various maintenance events, occasions, and visits) and what appeared to be possibly inconsistent application of these measures across studies. It seems reasonable that attempts have been made to refine the terms of prosthetic success to arrive at potentially more sensitive definitions, such as percentage of prostheses with no major modification; however, a lack of consensus on this has resulted in difficulty in interpreting and pooling important treatment outcomes. The review of prosthetic outcomes in the present study has been hampered to such a degree that it may prove impossible to determine the extent to which the apparently widely ranging differences in prosthetic maintenance across prosthetic types actually reflect important differences between groups; such differences may simply reflect differences in the application of the outcome measures. Ultimately, the best understanding of differences in prosthetic success and/or maintenance between prosthesis types will arise from RCTs assessing these outcomes or possibly from well-designed cohort studies with different prosthesis type groups. As noted, among the RCTs assessing removable overdenture designs, there was preliminary evidence that variation in prosthetic maintenance can be due to variation in prosthetic design, in particular design of the attachment mechanism.[10,46,60,62]

The present review supported a previously documented observation[82] that fixed prostheses in the maxilla have been found to enjoy a higher success when compared to removable maxillary prostheses. As noted, the available evidence was insufficient to warrant a hypothesis test in this regard. However, the evidence[28] did provide substantial clues that the most likely reason for the difference in implant survival was not the removable prosthesis design. The lower rates of implant survival experienced in the removable maxillary overdenture groups appeared to originate as a direct consequence of compromised preoperative bone volume in these groups compared to a more favorable residual ridge morphology reported in the fixed prosthesis group. Instead of calling into question the removable prosthesis design, the authors of that study suggested the possible merit of utilizing preoperative assessment for considering either bone augmentation or a reduced number and length of implants in cases where a fixed prosthesis may not be possible.

The statistically significant finding that implant survival in the mandible exceeds outcomes in the maxilla also reinforces long-established site-specific evidence. However, this finding simply reinforces established evidence of somewhat elevated vulnerability of the edentulous maxilla for implant failure when compared to consistently very high success rates achieved for the edentulous mandible[82]; the difference was not found to be due to prosthetic design features.

Finally, this study describes a systematic review of studies specifying implant survival and/or success outcomes by the type of prosthesis in the edentulous arch. An RCT is the optimal study design for testing the hypothesis that oral implant survival and success outcomes do not vary by prosthesis type. In correct anticipation of a dearth of RCT evidence, the preferred approach set by the original SSID working group suggested the reviews be designed to include as broad as possible a base of evidence to answer each of the 8 questions. Despite necessary tightening of the criteria through the review process for this PICO question, more than 300 papers still required full-text review to determine the final inclusion of the 72 applicable papers. The process of establishing and tightening criteria in a systematic review cannot be avoided, but it must be acknowledged to be one that is fraught with an undetermined risk of introducing bias into the process of selecting papers for review and so into the results.

The results of this study reveal that there cannot yet be an unequivocal consensus on the optimal type of prosthesis for the edentulous arch. Furthermore, most of the evidence included in the present review was published very recently, so what is considered current evidence today will almost certainly need to be updated continually. Clinicians should continue to be well read so as to be able to base implant prosthodontic treatment on established protocols.

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SECTION 5
CONSENSUS REPORT

Does the type of implant prosthesis affect outcomes for the completely edentulous arch?

Members of Section 5 evaluated the systematic review on the outcomes of various implant prostheses for the completely edentulous arch. The focused PICO question addressed by the authors, Ross Bryant and David MacDonald-Jankowski, of the evidence-based systematic review is: Does the type of implant prosthesis affect outcomes for the completely edentulous arch?

1. Does the section agree that the systematic review is complete and accurate?

The overall conclusions of the systematic review were that there is compelling evidence to support the restoration of mandibular implants irrespective of prosthesis type and that there is not sufficient evidence implicating prosthesis type as a determinant of implant survival. The section's discussion of the systematic review revealed a general consensus that the review was nearly complete and very accurate.

The review question was fully investigated and detailed analyses of various measured outcomes were completed. However, the scope of the included meta-analysis was limited to consideration of the effect of prosthesis type (fixed versus removable) on implant survival. The section agreed that, among the included studies, crucial observations were present and a sufficient clinical experience was generally represented.

The section reviewed the available literature by further examination of electronic databases and by hand searches and found that 2 additional papers could have been added to the systematic review prior to the 2005 closing date. The first paper (Naert I. The influence of attachment systems on implant-retained mandibular overdentures. In: Feine JS, Carlsson GE (eds). Implant Overdentures: The Standard of Care for Edentulous Patients. Chicago: Quintessence, 2003:99–109) presented 10-year implant survival data for this clinical situation. This paper incorporated data from a publication that had already been included in the systematic review's analysis. The second paper, "Effectiveness of three treatment modalities for the edentulous mandible. A five-year randomized clinical trial" (Raghoebar GM, Meijer HJ, Stegenga B, van't Hof MA, van Oort RP, Vissink A. Clin Oral Implants Res 2000;11:195–201), also contributed implant survival data to the review. However, the high survival rate data presented in this paper did not alter the results of the systematic review.

2. Has any new information been generated or discovered since the review cutoff time?

The section identified 8 additional papers that addressed the review topic. When they were considered by full text review, 3 papers were found to meet the systematic review criteria. The first, "Implant-retained mandibular overdentures versus conventional dentures: 10 years of care and aftercare" (Visser A, Meijer HJ, Raghoebar GM, Vissink A. Int J Prosthodont 2006;19:271–278), supported the systematic review findings that implants associated with mandibular overdentures survive at a high rate for 10 years. The second paper (Krennmair G, Weinlander M, Krainhofner M, Piehslinger E. Implant-supported mandibular overdentures retained with ball or telescopic crown attachments: A 3-year prospective study. Int J Prosthodont 2006;19:164–170) examined the mechanism of overdenture attachment to mandibular implants and also reported high implant survival rate.

A third additional paper (Jemt T, Johansson J. Implant treatment in the edentulous maxillae: A 15-year follow-up study on 76 consecutive patients provided with fixed prostheses. Clin Implant Dent Relat Res 2006;8:61–69) provides new and important insight into survival of implants supporting maxillary fixed dentures. The authors reported a high implant survival among 76 consecutively treated patients following 15 years of evaluation. This supports evidence included in the systematic review that maxillary endosseous implants supporting fixed prostheses will survive into a second decade of function. Comparative information on the effect of prosthesis type was not found in the recent literature.

3. Does the section agree with the interpretation and conclusion of the reviewers?

The systematic review focused on the single outcome of implant survival. The interpretation of this subset of available data was restricted to the conclusions that (1) maxillary and mandibular fixed prostheses, and mandibular removable prostheses, are associated with high mean implant survival over 5 to 10 years, (2) no difference was found for implant survival when mandibular fixed and removable prostheses were compared, and (3) there was insufficient evidence (consistent with the guidelines of the systematic review) to compare the effect of maxillary fixed and removable prostheses on implant survival. There was unanimous agreement regarding these initial conclusions and, moreover, the addition of the 2 papers published prior to 2006 and the 3 papers published after 2006 did not affect the result of the systematic review, nor did they alter the section's generalized support of the conclusions.

The section did find sufficient cause to consider in detail 5 key points that must be included in the interpretation of the data:

1. All of the observations made in the various studies are limited in their temporal interpretation. For example, it is not possible to extrapolate data from a 5-year study to a 10-year timepoint. Fortunately, when considering the present PICO question for the edentulous mandible and maxilla, there are data that present 10-year information.
2. Given the rapid evolution of implant design and components, many of the studies reviewed reported data from implants that are no longer readily available in the dental marketplace. Thus, any interpretation of implant survival data must accept that implant design factors are but one of many factors affecting survival.
3. There were insufficient data to support an analysis based on implant success.
4. This systematic review included data from studies with a wide range of potential explanatory variables. Examples include patient factors such as age, sex, and medical conditions; local factors such as bone quantity; and additional factors such as clinician experience and training. Some of these variables were captured by the reviewers' analysis of the original reports, but were not included in the present analysis of implant survival.
5. The data for implant survival present in the reviewed papers represented the result of implants lost prior to second stage surgery or abutment connection as well as implants lost after prosthesis connection. It is generally understood that approximately half of all implant failures occur prior to second stage surgery (Goodacre et al, 2001) [Au: Please supply complete reference; could not find in PubMed]. Therefore, it is possible to re-analyze the data to exclude implant loss prior to prosthesis loading. However, because implant survival rates were high among the majority of studies, such a recalculation of implant survival should not change the general conclusions of this analysis of available data.

4. What further research needs to be done relative to the PICO question?

The section first considered whether critical information regarding the PICO question was lacking. First and foremost, there is limited information available regarding the survival of implants supporting maxillary removable prostheses. Second, there are no data on the survival of implants beyond 20 years for fixed mandibular prostheses or beyond 15 years for implants supporting fixed prostheses in the edentulous maxilla. For removable mandibular prostheses, no data are available beyond 10 years.

Next, the section considered whether essential information was omitted. The section unanimously agreed that it is critical to review the available data concerning patient-based outcomes. There are issues of satisfaction, economics, and quality of life that may be indispensable to the clinical decision to place a fixed or removable prosthesis in the edentulous mandible or maxilla.

Several specific suggestions concerning future research also were made by the section. Well-designed and controlled effectiveness studies are needed to better extrapolate these findings beyond the tightly controlled environment of the included clinical investigations.

Emerging technologies may have an impact on future decisions to place fixed or removable prostheses in the restoration of the edentulous arches with implants. Currently, several new technologies are available to produce metal frameworks, provide ceramic veneering materials, or to affect the connection of overdentures to implants. In large part, the reviewed literature included the analysis of acrylic resin denture teeth processed to metal superstructures for fixed prostheses or within acrylic resin overdentures.

The observation of high implant survival rates for almost all clinical situations involving the restoration of the edentulous arches using implants underscores the dichotomy between high success and low utilization. This observation was made by several section participants and prompted the request for future studies to illuminate the factors that control access to care.

To continue the broader investigation of the PICO question, it is essential that the prosthetic outcomes be analyzed and reported. For this to be achieved, the section identified a critical need to broadly and uniformly define "prosthetic complication" and "prosthetic failure" in standard terms so these can be reported in a standardized manner.

The systematic review included papers that identify experimental variables that may be risk factors for implant loss in individual patients. It is also crucial that future analysis focus on the relationship between these variables and clinical outcomes. A comprehensive assessment of risk for implant loss may provide information to aid clinicians in making individual patient decisions.

5. How can the information from the systematic review be applied for patient management?

The data indicate that mandibular edentulous arch treatment decisions can be based on criteria other than prosthesis type. This reinforces the need for additional information regarding patient outcomes with different treatment modalities.

There are insufficient data to guide decisions regarding prosthesis type for implant-supported restoration of the edentulous maxilla. However, fixed prostheses in the maxilla are associated with a good prognosis. Additional evaluation of existing data will provide further insights into patient, local, and clinician factors that are affected by or, inversely, affect the prosthesis type for restoration of the edentulous arch.

WEB ONLY

Table W1 Excluded Full-text Studies by Author and Reasons for Excluding (n = 261*)

Excluded Studies (alphabetical by author)	Exclusion codes	Key table 4
Adell R, Lekholm U, Brånemark PI, Lindhe J, Rockler B, Eriksson B, Lindvall AM, Yoneyama T, Sbordone L. Marginal tissue reactions at osseointegrated titanium fixtures. Swed Dent J Suppl 1985;28:175–181.	L	P
Adell R. Tissue integrated prostheses in clinical dentistry. Int Dent J 1985;35:259–265.	R	
Ahren S, Kahnberg KE. The adaptation of implant-supported superstructures to the alveolar crest: A follow-up of 49 cases. Implant Dent 2001;10:172–177.	P	
Albrektsson T, Dahl E, Enbom L, Engevall S, Engquist B, Eriksson AR, Feldmann G, Freiberg N, Glantz PO, Kjellman O, et al. Osseointegrated oral implants. A Swedish multicenter study of 8139 consecutively inserted Nobelpharma implants. J Periodontol 1988;59:287–296.	F	
Albrektsson T. A multicenter report on osseointegrated oral implants. J Prosthet Dent 1988;60:75–84.	F	
Allen PF, McMillan AS, Smith DG. Complications and maintenance requirements of implant supported prostheses provided in a UK dental hospital. Br Dent J 1997;182:298–302.	L	
Aparicio C. The use of the Periotest value as the initial success criteria of an implant: 8-year report. Int J Periodontics Restorative Dent 1997;17:150–161.	P	OO
Arlin ML. Analysis of 435 screw-vent dental implants placed in 161 patients: Software enhancement of clinical evaluation. Implant Dent 2002;11:58–66.	P	
Attard NJ, Zarb GA. Long-term treatment outcomes in edentulous patients with implant overdentures: The Toronto study. Int J Prosthodont 2004;17:425–433.	M	
Attard NJ, Zarb GA. Long-term treatment outcomes in edentulous patients with implant-fixed prostheses: The Toronto study. Int J Prosthodont 2004;17:417–424.	M	
Attard NJ, Wei X, Laporte A, Zarb GA, Ungar WJ. A cost minimization analysis of implant treatment in mandibular edentulous patients. Int J Prosthodont 2003;16:271–276.	OO	
Babbush CA, Shimura M. Five-year statistical and clinical observations with the IMZ two-stage osteointegrated implant system. Int J Oral Maxillofac Implants 1993;8:245–253.	M	
Bain CA, Moy PK. The association between the failure of dental implants and cigarette smoking. Int J Oral Maxillofac Implants 1993;8:609–615.	P	
Balshi TJ. An analysis and management of fractured implants: A clinical report. Int J Oral Maxillofac Implants 1996;11:660–666.	P	
Bambarra GE. The attachment-retained overdenture. New York State Dent J 2004;12:30–33.	R	
Barber HD, Seckinger RJ, Silverstein K, Abughazaleh K. Comparison of soft tissue healing and osseointegration of IMZ implants placed in one-stage and two-stage techniques: A pilot study. Implant Dent 1996;5:11–14.	P	
Bass SL, Triplett RG. The effects of preoperative resorption and jaw anatomy on implant success. A report of 303 cases. Clin Oral Implants Res 1991;2:193–198.	P	
Becktor JP, Isaksson S, Sennerby L. Survival analysis of endosseous implants in grafted and nongrafted edentulous maxillae. Int J Oral Maxillofac Implants 2004;19:107–115.	F	
Behr M, Lang R, Leibrock A, Rosentritt M, Handel G. Complication rate with prosthodontic reconstructions on ITI and IMZ dental implants. Internationales Team fur Implantologie. Clin Oral Implants Res 1998;9:51–58.	L	P

Table W1 Excluded Full-text Studies by Author and Reasons for Excluding (n = 261*)

Excluded Studies (alphabetical by author)	Exclusion codes	Key table 4
Bergendal T, Engquist B. Implant-supported overdentures: A longitudinal prospective study. Int J Oral Maxillofac Implants 1998;13:253–262.	M	
Bergendal B, Palmqvist S. Laser-welded titanium frameworks for implant-supported fixed prostheses: A 5-year report. Int J Oral Maxillofac Implants 1999;14:69–71.	M	
Block MS, Kent JN. Cylindrical HA-coated implants—8-year observations. Compend Suppl 1993;(15):S526–S532.	P	
Block MS, Kent JN. Factors associated with soft- and hard-tissue compromise of endosseous implants. J Oral Maxillofac Surg 1990;48:1153–1160.	P	
Block MS, Kent JN. Long-term follow-up on hydroxylapatite-coated cylindrical dental implants: A comparison between developmental and recent periods. J Oral Maxillofac Surg 1994;52:937–943.	P	
Brånemark PI, Hansson BO, Adell R, et al. Osseointegrated implants in the treatment of the edentulous jaw. Experience from a 10-year period. Scand J Plast Reconstr Surg Suppl 1977;16:1–132.	G	
Brocard D, Barthet P, Baysse E, et al. A multicenter report on 1,022 consecutively placed ITI implants: A 7-year longitudinal study. Int J Oral Maxillofac Implants 2000;15:691–700.	G	
Brook I M, Freeman C, Lamb DJ 24-8-2002. Ref Type: Personal Communication	R	
Buchs AU, Hahn J, Vassos DM. Efficacy of threaded hydroxyapatite-coated implants in the anterior mandible supporting overdentures. Implant Dent 1996;5:188–192.	G	
Buchs AU, Hahn J, Vassos DM. Efficacy of threaded hydroxyapatite-coated implants placed in the anterior mandible. Implant Dent 1995;4:272–275.	P	
Buchs AU, Hahn J, Vassos DM. Interim clinical study report: A threaded, hydroxylapatite-coated implant—five-year post-restoration safety and efficacy. J Oral Implantol 1995;21:266–274.	P	
Burns DR, Unger JW, Elswick RK, Beck DA. Prospective clinical evaluation of mandibular implant overdentures: Part I—Retention, stability, and tissue response. J Prosthet Dent 1995;73:354–363.	LR	
Burns D, Unger JW, Elswick RK Jr, Gigilo JA. Prospective clinical evaluation of mandibular implant overdentures: Part II - Patient satisfaction and preferences. J Prosthet Dent 1994;73:364–369.	LR	
Burns DR, Unger JW, Elswick RK, Beck DA. PJ Prospective clinical evaluation of mandibular implant overdentures: Part I - Retention, stability, and tissue response. J Prosthet Dent 1995;73:354–363.	LR	
Buser D, Mericske-Stern R, Bernard JP, Behneke A, Behneke N, Hirt HP, Belser UC, Lang NP. Long-term evaluation of non-submerged ITI implants. Part 1: 8-year life table analysis of a prospective multi-center study with 2359 implants. Clin Oral Implants Res 1997;8:161–172.	P	
Callan DP, O'Mahony A, Cobb CM. Loss of crestal bone around dental implants: A retrospective study. Implant Dent 1998;7:258–266.	P	
Callan DP. Dental implants and coronal bone loss: An evaluation of 350 implants. Dent Today 1997;16:54–59.	P	
Callan DP. Maintaining cosmetics and marginal bone with a dental implant. Implant Dent 2000;9:154–161.	P	
Campelo LD, Camara JR. Flapless implant surgery: A 10-year clinical retrospective analysis. Int J Oral Maxillofac Implants 2002;17:271–276.	P	
Carr AB, Choi YG, Eckert SE, Desjardins RP. Retrospective cohort study of the clinical performance of 1-stage dental implants. Int J Oral Maxillofac Implants 2003;18:399–405.	P	L
Carter GM, Hunter KM. Six years' experience with Brånemark osseointegrated implants. N Z Dent J 1995;91:44–48.	P	L
Chan MF, Johnston C, Howell RA, Cawood JI. Prosthetic management of the atrophic mandible using endosseous implants and overdentures: A six year review. Br Dent J 1995;179:329–337.	G	
Chapman RJ, Grippo W. The locking taper attachment for implant abutments: Use and reliability. Implant Dent 1996;5:257–261.	P	
Chaushu G, Schwartz-Arad D. Full-arch restoration of the jaw with fixed ceramo-metal prosthesis: Late implant placement. J Periodontol 1999;70:90–94.	LB	
Chaytor DV, Zarb GA, Schmitt A, Lewis DW. The longitudinal effectiveness of osseointegrated dental implants. The Toronto Study: Bone level changes. Int J Periodontics Restorative Dent 1991;11:112–125.	F	
Chiarenza AR. Retrospective observations on the influence of bone type in determining the nature of bone implant interface. Int J Oral Implantol 1989;6:43–48.	R	
Chuang SK, Tian L, Wei LJ, Dodson TB. Kaplan-Meier analysis of dental implant survival: A strategy for estimating survival with clustered observations. J Dent Res 2001;80:2016–2020.	P	
Chuang SK, Tian L, Wei LJ, Dodson TB. Predicting dental implant survival by use of the marginal approach of the semi-parametric survival methods for clustered observations. J Dent Res 2002;81:851–855.	P	
Chuang SK, Wei LJ, Douglass CW, Dodson TB. Risk factors for dental implant failure: A strategy for the analysis of clustered failure-time observations. J Dent Res 2002;81:572–577.	P	
Chuang SK, Didson TB. 2000. Ref Type: Personal Communication	R	
Cloyd JS. Mandibular overdentures retained with porous-surfaced implants. Dent Today 2003;22:100–105.	CR	
Cochran D. Implant therapy I. Ann Periodontol 1996;1:707–791.	R	
Cochran DL. A comparison of endosseous dental implant surfaces. J Periodontol 1999;70:1523–1539.	OS	
Comfort MB, Chu FC, Chai J, Wat PY, Chow TW. A 5-year prospective study on small diameter screw-shaped oral implants. J Oral Rehabil 2005;32:341–345.	CR	

Table W1 Excluded Full-text Studies by Author and Reasons for Excluding (n = 261*)

Excluded Studies (alphabetical by author)	Exclusion codes	Key table 4
Cossman MH. 1995. Ref Type: Personal Communication	R	
Cranin AN, Rabkin M. Endosteal oral implants. A retrospective radiographic study. Dent Radiogr Photogr 1976;49:3–13.	NT	P
Cranin AN, Rabkin MF, Garfinkel L. A statistical evaluation of 952 endosteal implants in humans. J Am Dent Assoc 1977;94:315–320.	NT	P
Cranin AN, Sher J, Schilb TP. The transosteal implant: A 17-year review and report. J Prosthet Dent 1986;55:709–718.	NT	
Cranin AN. The anchor endosteal implant. Dent Clin North Am 1980;24:505-519.	NT	
Cummings J, Arbree NS. Prosthodontic treatment of patients receiving implants by predoctoral students: Five-year follow-up with the IMZ system. J Prosthet Dent 1995;74:56–59.	L	P
Cune MS, De Putter C, Hoogstraten J. Treatment outcome with implant-retained overdentures: Part I—Clinical findings and predictability of clinical treatment outcome. J Prosthet Dent 1994;72:144–151.	L	
Cune MA, de Putter C. A comparative evaluation of some outcome measures of implant systems and suprastructure types in mandibular implant-overdenture treatment. Int J Oral Maxillofac Implants 1994;9:548–555.	L	
Dario LJ. The Spline implant interface: Analysis and initial clinical experiences. Compend Contin Educ Dent 1998;19:896–898.	NC	CR
Davarpanah M, Martinez H, Etienne D, Zabalegui I, Mattout P, Chiche F, Michel JF. A prospective multicenter evaluation of 1,583 3i implants: 1- to 5-year data. Int J Oral Maxillofac Implants 2002;17:820–828.	P	
Davis DM, Packer ME, Watson RM. Maintenance requirements of implant-supported fixed prostheses opposed by implant-supported fixed prostheses, natural teeth, or complete dentures: A 5-year retrospective study. Int J Prosthodont 2003;16:521–523.	NC	
Davis DM. Implant supported overdentures—The King's experience. J Dent 1997;25 Suppl 1:33–37.	L	
Demitri V, Polini F, Robiony M, Politi M. Prognostic trend in advanced implant surgery. Minerva Stomatol 2002;51:65–72.	P	
den Dunnen AC, Slagter AP, de Batt C, Kalk W. Adjustments and complications of mandibular overdentures retained by four implants: A comparison between superstructures with and without cantilever extensions. Int J Prosthodont 1998;11:307–311.	L	
Dhariwal DK, Gibbons AJ, Hodder SC. 2002. Ref Type: Personal Communication	OO	
d'Hoedt B, Schulte W. A comparative study of results with various endosseous implant systems. Int J Oral Maxillofac Implants 1989;4:95–105.	P	
Dove J, Sheridan P. Implants proved successful in atrophied mandibles. J Am Dent Assoc 1990;121:288.	L	
Drago CJ. Rates of osseointegration of dental implants with regard to anatomical location. J Prosthodont 1992;1:29–31.	P	
Eckert SE, Meraw SJ, Cal E, Ow RK. Analysis of incidence and associated factors with fractured implants: A retrospective study. Int J Oral Maxillofac Implants 2000;15:662–667.	OO	P
Ekfeldt A, Johansson L-A, Isaksson S. Implant-supported overdenture therapy: A retrospective study. Int J Prosthodont 1997;10:366–374.	L	
Ellies LG, Hawker PB. The prevalence of altered sensation associated with implant surgery. Int J Oral Maxillofac Implants 1993;8:674–679.	OO	L
Ellies LG. Altered sensation following mandibular implant surgery: A retrospective study. J Prosthet Dent 1992;68:664–671.	OO	L
Engquist B, Bergendal T, Kallus T, Linden U. A retrospective multicenter evaluation of osseointegrated implants supporting overdentures. Int J Oral Maxillofac Implants 1988;3:129–134.	L	
Evian CI. A comparison of hydroxyapatite-coated Micro-Vent and pure titanium Swede-Vent implants. Int J Oral Maxillofac Implants 1996;11:639–644.	P	
Falomo OO, Hobkirk JA. A retrospective survey of patients treated with subperiosteal and endosseous implants. J Prosthet Dent 1988;60:587–590.	NT	
Feldman S, Boitel N, Weng D, Kohles SS, Stach RM. Five-year survival distributions of short-length (10 mm or less) machined-surfaced and Osseotite implants. Clin Implant Dent Relat Res 2004;6:16–23.	P	
Ferrigno N, Laureti M, Fanali S, Grippaudo G. A long-term follow-up study of non-submerged ITI implants in the treatment of totally edentulous jaws. Part I: Ten-year life table analysis of a prospective multicenter study with 1286 implants. Clin Oral Implants Res 2002;13:260–273.	G	
Fiorellini JP, Weber HP. Clinical trials on the prognosis of dental implants. Periodontol 2000 1994;4:98–108.	R	
Fortin Y, Sullivan RM, Rangert BR. The Marius implant bridge: Surgical and prosthetic rehabilitation for the completely edentulous upper jaw with moderate to severe resorption: A 5-year retrospective clinical study. Clin Implant Dent Relat Res 2002;4:69–77.	LB	
Freeman C, Brook I, Joshi R. Long-term follow-up of implant-stabilised overdentures. Eur J Prosthodont Restor Dent 2001;9:147–150.	LB	
Friberg B, Grondahl K, Lekholm U, Brånemark P-I. Long-term follow-up of severely atrophic edentulous mandibles reconstructed with short Brånemark implants. Clin Implant Dent Relat Res 2000;2:184–189.	LB	
Friberg B, Nilson H, Olsson M, Palmquist C. Mk II: The self-tapping Brånemark implant: 5-year results of a prospective 3-center study. Clin Oral Implants Res 1997;8:279–285.	P	
Fugazzotto PA, Gulbransen HJ, Wheeler SL, Lindsay JA. The use of IMZ osseointegrated implants in partially and completely edentulous patients: Success and failure rates of 2,023 implant cylinders up to 60+ months in function. Int J Oral Maxillofac Implants 1993;8:617–621.	L	

Table W1 Excluded Full-text Studies by Author and Reasons for Excluding (n = 261*)		
Excluded Studies (alphabetical by author)	**Exclusion codes**	**Key table 4**
Fugazzotto PA, Vlassis J, Butler B. ITI implant use in private practice: Clinical results with 5,526 implants followed up to 72+ months in function. Int J Oral Maxillofac Implants 2004;19:408-–412.	P	
Fugazzotto PA, Wheeler SL, Lindsay JA. Success and failure rates of cylinder implants in type IV bone. J Periodontol 1993;64:1085–1087.	P	
Garg AK. Success of dental implants in the geriatric patient. Dent Implantol Update 2002;13:25–31.	R	
Garlini G, Bianchi C, Chierichetti V, Sigurta D, Maiorana C, Santoro F. Retrospective clinical study of Osseotite implants: Zero- to 5-year results. Int J Oral Maxillofac Implants 2003;18:589–593.	P	
Geertman ME, van Waas MA, van 't Hof MA, Kalk W. Denture satisfaction in a comparative study of implant-retained mandibular overdentures: A randomized clinical trial. Int J Oral Maxillofac Implants 1996;11:194–200.	L	
Golec TS, Krauser JT. Long-term retrospective studies on hydroxyapatite coated endosteal and subperiosteal implants. Dent Clin North Am 1992;36:39–65.	P	
Goodacre CJ, Kan JY, Rungcharassaeng K. Clinical complications of osseointegrated implants. J Prosthet Dent 1999;81:537–552.	R	
Gross HN. A thirty-two year implant retrospect and prospect. N Y J Dent 1980;50:219–221.	R	
Haas R, Mensdorff-Pouilly N, Mailath G, Bernhart T. Five-year results of maxillary intramobile Zylinder implants. Br J Oral Maxillofac Surg 1998;36:123–128.	G	
Haas R, Mensdorff-Pouilly N, Mailath G, Watzek G. Survival of 1,920 IMZ implants followed for up to 100 months. Int J Oral Maxillofac Implants 1996;11:581–588.	I	
Hahn J, Vassos DM. A five year clinical evaluation showing optimum results in dental implants. J Dent Symp 1993;1:34–37.	P	
Hahn J, Vassos DM. Long-term efficacy of hydroxyapatite-coated cylindrical implants. Implant Dent 1997;6:111–115.	P	
Hansson BO. Success and failure of osseointegrated implants in the edentulous jaw. Swed Dent J Suppl 1977;1:1–101.	P	M
Hartman GA, Cochran DL. Initial implant position determines the magnitude of crestal bone remodeling. J Periodontol 2004;75:572–577.	F	
Hedkvist L, Mattsson T, Hellden LB. Clinical performance of a method for the fabrication of implant-supported precisely fitting titanium frameworks: A retrospective 5- to 8-year clinical follow-up study. Clin Implant Dent Relat Res 2004;6:174–180.	P	M
Hellden L, Ericson G, Elliot A, Fornell J, Holmgren K, Nilner K, Olsson CO. A prospective 5-year multicenter study of the Cresco implantology concept. Int J Prosthodont 2003;16:554–562.	P	
Herrmann I, Lekholm U, Holm S, Karlsson S. Impact of implant interdependency when evaluating success rates: A statistical analysis of multicenter results. Int J Prosthodont 1999;12:160–166.	P	
Herrmann I, Lekholm U, Holm S, Kultje C. Evaluation of patient and implant characteristics as potential prognostic factors for oral implant failures. Int J Oral Maxillofac Implants 2005;20:220–230.	P	NC
Hertel RC, Kalk W. Influence of the dimensions of implant superstructure on peri-implant bone loss. Int J Prosthodont 1993;6:18–24.	NC	
Hollender L, Rockler B. Radiographic evaluation of osseointegrated implants of the jaws. Dentomaxillofac Radiol 1980;9:91–95.	NH	
Hooghe M, Naert I. Implant supported overdentures - The Leuven experience. J Dent 1997;25 Suppl 1:25–32.	LR	
Hoshaw SJ, Brunski JB, Cochran GVB. Mechanical loading of Brånemark implants affects interfacial bone modeling and remodeling. Int J Oral Maxillofac Implants 1994;9:345–360.	NH	
Hulterstrom M, Nilsson U. Cobalt-chromium as a framework material in implant-supported fixed prostheses: A 3-year follow-up. Int J Oral Maxillofac Implants 1994;9:449–454.	L	
Inan O, Aykent F, Alptekin N. Implant-supported overdenture therapy: A 3- to 8-year prospective study. Implant Dent 2000;9:369–373.	M	
Jaffin RA, Berman CL. The excessive loss of Brånemark fixtures in type IV bone: A 5-year analysis. J Periodontol 1991;62:2–4.	P	
Jagger RG, Shaikh S, Jagger DC. Clinical effectiveness of mandibular implant-retained overdentures. Prim Dent Care 2001;8:19–24.	LB	
Jemt T, Book K. Prosthesis misfit and marginal bone loss in edentulous implant patients. Int J Oral Maxillofac Implants 1996;11:620–625.	NC	
Jemt T, Linden B. Fixed implant-supported prostheses with welded titanium frameworks. Int J Periodontics Restorative Dent 1992;12:177–183.	L	
Jemt T. Implant treatment in elderly patients. Int J Prosthodont 1993;6:456–461.	L	
Jemt T. Implant treatment in resorbed edentulous upper jaws. Clin Oral Implants Res 1993;4:187–194.	L	
Johns RB, Jemt T, Heath MR, et al. A multicenter study of overdentures supported by Brånemark implants. Int J Oral Maxillofac Implants 1992;7:513-522.	L	
Jones JD, Lupori J, Van Sickels JE, Gardner W. A 5-year comparison of hydroxyapatite-coated titanium plasma-sprayed and titanium plasma-sprayed cylinder dental implants. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 1999;87:649–652.	P	
Kallus T, Bessing C. Loose gold screws frequently occur in full-arch fixed prostheses supported by osseointegrated implants after 5 years. Int J Oral Maxillofac Implants 1994;9:169–178.	NC	M

Table W1 Excluded Full-text Studies by Author and Reasons for Excluding (n = 261*)

Excluded Studies (alphabetical by author)	Exclusion codes	Key table 4
Kao SY, Yeung TC, Hung KF, Chou IC, Wu CH, Chang RC. Transpositioned flap vestibuloplasty combined with implant surgery in the severely resorbed atrophic edentulous ridge. J Oral Implantol 2002;28:194–199.	L	
Karabuda C, Tosun T, Ermis E, Ozdemir T. Comparison of 2 retentive systems for implant-supported overdentures: Soft tissue management and evaluation of patient satisfaction. J Periodontol 2002;73:1067–1070.	OO	
Karlsson S, Jemt T. Adaptive changes of masticatory movement characteristics after rehabilitation with osseointegrated fixed prostheses in the edentulous jaw: A 10-year follow-up study. Int J Oral Maxillofac Implants 1991;6:259–263.	OO	
Karoussis IK, Bragger U, Salvi GE, Burgin W, Lang NP. Effect of implant design on survival and success rates of titanium oral implants: A 10-year prospective cohort study of the ITI Dental Implant System. Clin Oral Implants Res 2004;15:8–17.	P	
Karoussis IK, Salvi GE, Heitz-Mayfield LJ, Bragger U, Hämmerle CH, Lang NP. Long-term implant prognosis in patients with and without a history of chronic periodontitis: A 10-year prospective cohort study of the ITI Dental Implant System. Clin Oral Implants Res 2003;14:329–339.	P	
Kent JN, Block MS, Finger IM, Guerra L, Larsen H, Misiek DJ. Biointegrated hydroxylapatite-coated dental implants: 5-year clinical observations. J Am Dent Assoc 1990;121:138–144.	P	L
Kiener P, Oetterli M, Mericske E, Mericske-Stern R. Effectiveness of maxillary overdentures supported by implants: Maintenance and prosthetic complications. Int J Prosthodont 2001;14:133–140.	LB	
Kirsch A, Mentag PJ. The IMZ endosseous two phase implant system: A complete oral rehabilitation treatment concept. J Oral Implantol 1986;12:576–589.	L	
Kirsch A. The two-phase implantation method using IMZ intramobile cylinder implants. J Oral Implantol 1983;11:197–210.	R	
Kondell PA, Landt H, Nordenram A, Carlsson B, Danielsson K. The tissue-integrated prosthesis in the treatment of edentulous patients. A follow-up study. Swed Dent J 1988;12:11–16.	P	
Kondell PA, Nordenram A, Landt H. Titanium implants in the treatment of edentulousness: Influence of patient's age on prognosis. Gerodontics 1988;4:280–284.	L	
Krekmanov L, Kahn M, Rangert B, Lindstrom H. Tilting of posterior mandibular and maxillary implants for improved prosthesis support. Int J Oral Maxillofac Implants 2000;15:405–414.	P	
Krennmair G, Furhauser R, Krainhofner M, Weinlander M, Piehslinger E. Clinical outcome and prosthodontic compensation of tilted interforaminal implants for mandibular overdentures. Int J Oral Maxillofac Implants 2005;20:923–929.	LB	
Krennmair G, Ulm C. The symphyseal single-tooth implant for anchorage of a mandibular complete denture in geriatric patients: A clinical report. Int J Oral Maxillofac Implants 2001;16:98–104.	L	
Kucey BK. Implant placement in prosthodontics practice: A five-year retrospective study. J Prosthet Dent 1997;77:171–176.	L	P
Kwakman JM, Voorsmit RA, Freihofer HP, van Waas MA, Geertman ME. Randomized prospective clinical trial of two implant systems for overdenture treatment: A comparison of the 2-year and 5-year results using the clinical implant performance scale. Int J Oral Maxillofac Surg 1998;27:94–98.	LB	
Lambrecht JT, Filippi A, Kunzel AR, Schiel HJ. Long-term evaluation of submerged and nonsubmerged ITI solid-screw titanium implants: A 10-year life table analysis of 468 implants. Int J Oral Maxillofac Implants 2003;18:826-–834.	P	
Lauc T, Krnic D, Katanec D. Implant failure: Regional versus cumulative evaluation. Coll Antropol 2000;24 Suppl 1:91–96.	P	
Lazzara R, Siddiqui AA, Binon P, Feldman SA, Weiner R, Phillips R, Gonshor A. Retrospective multicenter analysis of 3i endosseous dental implants placed over a five-year period. Clin Oral Implants Res 1996;7:73–83.	P	
Lazzara R. Esthetic excellence with implant abutments. Dent Econ 1993;83:83–84.	R	
Leimola-Virtanen R, Peltola J, Oksala E, Helenius H, Happonen RP. ITI titanium plasma-sprayed screw implants in the treatment of edentulous mandibles: A follow-up study of 39 patients. Int J Oral Maxillofac Implants 1995;10:373–378.	I	
Lemons JE. Unanticipated outcomes: Dental implants. Implant Dent 1998;7:351–354.	R	
Lill W, Thornton B, Reichsthaler J, Schneider B. Statistical analyses on the success potential of osseointegrated implants: A retrospective single-dimension statistical analysis. J Prosthet Dent 1993;69:176–185.	LB	
Lindquist LW. Prosthetic rehabilitation of the edentulous mandible. A longitudinal study of treatment with tissue-integrated fixed prostheses. Swed Dent J Suppl 1987;48:1–39.	RP	
Linkow LI, Kohen PA. Evaluation of 564 implant patients (1540 implants). Implantologist 1979;1:35–37.	NT	
Lozada JL, James RA, Boskovic M. HA-coated implants: Warranted or not? Compend Suppl 1993;(15):S539–S543.	P	
Lozada JL. Eight-year clinical evaluation of HA-coated implants. J Dent Symp 1993;1:67–69.	P	
Lundqvist S, Carlsson GE. Maxillary fixed prostheses on osseointegrated dental implants. J Prosthet Dent 1983;50:262–270.	L	
Machiko GW, Wagner JR. The mandibular full subperiosteal implant vs. root form fixtures in the symphysis. Implant Soc 1992;3:2–4.	R	
Manz MC. Factors associated with radiographic vertical bone loss around implants placed in a clinical study. Ann Periodontol 2000;5:137–151.	F	
Mau J, Behneke A, Behneke N, et al. Randomized multicenter comparison of 2 IMZ and 4 TPS screw implants supporting bar-retained overdentures in 425 edentulous mandibles. Int J Oral Maxillofac Implants 2003;18:835–847.	LB	
May R, Varney K. Implant dentistry: A success? Yes! (An analysis of one oral surgeon's first one thousand implants). Miss Dent Assoc J 1995;51:20.	P	
McDermott NE, Chuang SK, Woo VV, Dodson TB. Complications of dental implants: Identification, frequency, and associated risk factors. Int J Oral Maxillofac Implants 2003;18:848–855.	P	

Table W1 Excluded Full-text Studies by Author and Reasons for Excluding (n = 261*)

Excluded Studies (alphabetical by author)	Exclusion codes	Key table 4
McGlumphy EA, Peterson LJ, Larsen PE, Jeffcoat MK. Prospective study of 429 hydroxyapatite-coated cylindric omniloc implants placed in 121 patients. Int J Oral Maxillofac Implants 2003;18:82–92.	P	
Meffert RM. Pyrolite carbon-coated endosseous post-type dental implant. J Oral Implantol 1983;11:36–44.	R	
Melas F, Marcenes W, Wright PS. Oral health impact on daily performance in patients with implant-stabilized overdentures and patients with conventional complete dentures. Int J Oral Maxillofac Implants 2001;16:700–712.	OO	
Merickse-Stern R, Aerni D, Geering AH, Buser D. Long-term evaluation of non-submerged hollow cylinder implants. Clinical and radiographic results. Clin Oral Implants Res 2001;12:252–259.	P	NT
Mericske-Stern R, Oetterli M, Kiener P, Mericske E. A follow-up study of maxillary implants supporting an overdenture: Clinical and radiographic results. Int J Oral Maxillofac Implants 2002;17:678–686.	G	
Mericske-Stern R, Steinlin Schaffner T, Marti P, Geering AH. Peri-implant mucosal aspects of ITI implants supporting overdentures. A five-year longitudinal study. Clin Oral Implants Res 1994;5:9–18.	S	
Mericske-Stern R, Zarb GA. Overdentures: An alternative implant methodology for edentulous patients. Int J Prosthodont 1993;6:203–208.	S	
Mericske-Stern R. Clinical evaluation of overdenture restorations supported by osseointegrated titanium implants: A retrospective study. Int J Oral Maxillofac Implants 1990;5:375–383.	LB	S
Mericske-Stern R. Treatment outcomes with implant-supported overdentures: Clinical considerations. J Prosthet Dent 1998;79:66–73.	R	
Mew J. 1993. Ref Type: Personal Communication	R	
Misch LS, Misch CE. Denture satisfaction—A patient perspective. Int J Oral Implantol 1991;7:43–48.	R	
Miyashita Y, Arataki T, Nomura T, et al. Clinical evaluation of osseointegrated implants in Tokyo Dental College Hospital (third report): Long-term observation of functioning survival rate of fixtures. Bull Tokyo Dent Coll 2003;44:169–175.	LB	
Morgan KM, Chapman RJ. Retrospective analysis of an implant system. Compend Contin Educ Dent 1999;20:609-614.	P	
Morris HF, Ochi S, Crum P, Orenstein IH, Winkler S. AICRG, Part I: A 6-year multicentered, multidisciplinary clinical study of a new and innovative implant design. J Oral Implantol 2004;30:125–133.	P	
Murphy WM. Clinical and experimental bone changes after intraosseous implantation. J Prosthet Dent 1995;73:31–35.	R	
Naert I, Quirynen M, Hooghe M, van Steenberghe D. A comparative prospective study of splinted and unsplinted Brånemark implants in mandibular overdenture therapy: A preliminary report. J Prosthet Dent 1994;71:486–492.	LR	
Naert I, Quirynen M, van Steenberghe D, Darius P. A study of 589 consecutive implants supporting complete fixed prostheses. Part II: Prosthetic aspects. J Prosthet Dent 1992;68:949–956.	LB	
Naert IE, Hooghe M, Quirynen M, van Steenberghe D. The reliability of implant-retained hinging overdentures for the fully edentulous mandible. An up to 9-year longitudinal study. Clin Oral Investig 1997;1:119–124.	LB	S
Naert I, de Clercq M, Theuniers G, Schepers E. Overdentures supported by osseointegrated fixtures for the edentulous mandible: A 2.5-year report. Int J Oral Maxillofac Implants 1988;3:191–196.	L	
Naert I, Quirynen M, van Steenberghe D, Darius P. A comparative study between Brånemark and IMZ implants supporting overdentures: Prosthetic considerations. In: Laney WR, Tolman DE (eds). Tissue Integration in Oral, Orthopedic, and Maxillofacial Reconstruction. Chicago: Quintessence, 1992:179–193.	L	
Narhi TO, Hevinga M, Voorsmit RA, Kalk W. Maxillary overdentures retained by splinted and unsplinted implants: A retrospective study. Int J Oral Maxillofac Implants 2001;16:259–266.	LB	
Nentwig GH. Ankylos implant system: Concept and clinical application. J Oral Implantol 2004;30:171–177.	P	
Noack N, Willer J, Hoffmann J. Long-term results after placement of dental implants: Longitudinal study of 1,964 implants over 16 years. Int J Oral Maxillofac Implants 1999;14:748–755.	P	NT
Oakes KS, Christensen LC. Retrospective evaluation of osseointegrated implants for treatment of partial and full edentulism at Walter Reed Army Medical Center: Part I: Patient recall. Mil Med 1995;160:355–358.	P	
Oetterli M, Kiener P, Mericske-Stern R. A longitudinal study on mandibular implants supporting an overdenture: The influence of retention mechanism and anatomic-prosthetic variables on periimplant parameters. Int J Prosthodont 2001;14:536–542.	LB	S
Ortorp A. On titanium frameworks and alternative impression techniques in implant dentistry. Swed Dent J Suppl 2005;(169):3–88.	RP	
Palmqvist S, Owall B, Schou S. A prospective randomized clinical study comparing implant-supported fixed prostheses and overdentures in the edentulous mandible: Prosthodontic production time and costs. Int J Prosthodont 2004;17:231–235.	LR	
Palmqvist S, Sondell K, Swartz B, Svenson B. Marginal bone levels around maxillary implants supporting overdentures or fixed prostheses: A comparative study using detailed narrow-beam radiographs. Int J Oral Maxillofac Implants 1996;11:223–227.	L	
Palmqvist S, Sondell K, Swartz B. Implant-supported maxillary overdentures: Outcome in planned and emergency cases. Int J Oral Maxillofac Implants 1994;9:184–190.	LB	
Parel S. Implants and overdentures: The oseeointegrated approach with conventional and compromised applications. Int J Oral Maxillofac Implants 1986;1:93–99.	R	
Patrick D, Zosky J, Lubar R, Buchs A. Longitudinal clinical efficacy of Core-Vent dental implants: A five-year report. J Oral Implantol 1989;15:95–103.	P	

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Excluded Studies (alphabetical by author)	Exclusion codes	Key table 4
Patterson MK, Bulard RA, Larsen C, Rohrer MD. IMTEC implants: Clinical evaluation of 120 patients: 548 implants. J Okla Dent Assoc 1995;86:12–15.	P	
Payne AGT, Solomons YF, Tawse-Smith A, Lownie JF. Inter-abutment and peri-abutment mucosal enlargement with mandibular implant overdentures. Clin Oral Implants Res 2001;12:179–187.	R	
Payne AGT, Solomons YF. The prosthodontic maintenance requirements of mandibular mucosa- and implant-supported overdentures: A review of the literature. Int J Prosthodont 2000;13:238–245.	R	
Quirynen M, Alsaadi G, Pauwels M, Haffajee A, van Steenberghe D, Naert I. Microbiological and clinical outcomes and patient satisfaction for two treatment options in the edentulous lower jaw after 10 years of function. Clin Oral Implants Res 2005;16:277–287.	OO	
Quirynen M, Naert I, van Steenberghe D, Nys L. A study of 589 consecutive implants supporting complete fixed prostheses. Part I: Periodontal aspects. J Prosthet Dent 1992;68:655–663.	LB	
Quirynen M, Naert I, van Steenberghe D, Schepers E, Calberson L, Theuniers G, Ghyselen J, de Mars G. The cumulative failure rate of the Brånemark system in the overdenture, the fixed partial, and the fixed full prosthesis design: A prospective study on 1273 fixtures. J Head and Neck Pathol 1991;10:43–53.	L	
Ricci G, Aimetti M, Stablum W, Guasti A. Crestal bone resorption 5 years after implant loading: Clinical and radiologic results with a 2-stage implant system. Int J Oral Maxillofac Implants 2004;19:597–602.	P	
Romeo E, Lops D, Margutti E, Ghisolfi M, Chiapasco M, Vogel G. Long-term survival and success of oral implants in the treatment of full and partial arches: A 7-year prospective study with the ITI dental implant system. Int J Oral Maxillofac Implants 2004;19:247–259.	LB	S
Roos J, Sennerby L, Lekholm U, Jemt T, Grondahl K, Albrektsson T. A qualitative and quantitative method for evaluating implant success: A 5-year retrospective analysis of the Brånemark implant. Int J Oral Maxillofac Implants 1997;12:504–514.	P	
Rosenberg ES, Torosian J. An evaluation of differences and similarities observed in fixture failure of five distinct implant systems. Pract Periodontics Aesthet Dent 1998;10:687–698.	L	
Ryan PC. 1995. Ref Type: Personal Communication	R	
Saadoun AP, Le Gall MG. An 8-year compilation of clinical results obtained with Steri-Oss endosseous implants. Compend Contin Educ Dent 1996;17:669–674.	P	
Sandler PJ. 2003. Ref Type: Personal Communication	R	
Schlegel KD. Follow-up findings in oral implants. J Oral Implantol 1984;11:371–385.	NT	
Schmitt A, Zarb GA. The notion of implant-supported overdentures. J Prosthet Dent 1998;79:60-65.	M	
Schwartz-Arad D, Gulayev N, Chaushu G. Immediate versus non-immediate implantation for full-arch fixed reconstruction following extraction of all residual teeth: A retrospective comparative study. J Periodontol 2000;71:923–928.	P	I
Schwartz-Arad D, Kidron N, Dolev E. A long-term study of implants supporting overdentures as a model for implant success. J Periodontol 2005;76:1431–1435.	LB	
Schwartz-Arad D, Mardinger O, Levin L, Kozlovsky A, Hirshberg A. Marginal bone loss pattern around hydroxyapatite-coated versus commercially pure titanium implants after up to 12 years of follow-up. Int J Oral Maxillofac Implants 2005;20:238–244.	LB	
Scurria MS, Morgan ZV, Guckes AD, Li S, Koch G. Prognostic variables associated with implant failure: A retrospective effectiveness study. Int J Oral Maxillofac Implants 1998;13:400–406.	L	
Sennerby L, Carlsson GE, Bergman B, Warfvinge J. Mandibular bone resorption in patients treated with tissue-integrated prostheses and in complete-denture wearers. Acta Odontol Scand 1988;46:135–140.	OO	
Sethi A, Kaus T, Sochor P, Axmann-Krcmar D, Chanavaz M. Evolution of the concept of angulated abutments in implant dentistry: 14-year clinical data. Implant Dent 2002;11:41–51.	P	
Sethi A, Kaus T, Sochor P. The use of angulated abutments in implant dentistry: Five-year clinical results of an ongoing prospective study. Int J Oral Maxillofac Implants 2000;15:801–810.	P	
Setz J, Lee SH, Engel E. Retention of prefabricated attachments for implant stabilized overdentures in the edentulous mandible: An in vitro study. J Prosthet Dent 1998;80:323–329.	NH	
Shackleton JL, Carr L, Slabbert JC, Becker PJ. Survival of fixed implant-supported prostheses related to cantilever lengths. J Prosthet Dent 1994;71:23–26.	M	
Small IA. The fixed mandibular implant: A 6-year review. J Oral Maxillofac Surg 1993;51:1206–1210.	NT	
Small PN, Tarnow DP, Cho SC. Gingival recession around wide-diameter versus standard-diameter implants: A 3- to 5-year longitudinal prospective study. Pract Proced Aesthet Dent 2001;13:143–146.	P	
Snauwaert K, Duyck J, van Steenberghe D, Quirynen M, Naert I. Time dependent failure rate and marginal bone loss of implant supported prostheses: A 15-year follow-up study. Clin Oral Investig 2000;4:13–20.	L	
Sones AD. Complications with osseointegrated implants. J Prosthet Dent 1989;62:581–585.	R	
Spiekermann H, Jansen VK, Richter EJ. A 10-year follow-up study of IMZ and TPS implants in the edentulous mandible using bar-retained overdentures. Int J Oral Maxillofac Implants 1995;10:231–243.	LB	
Starr NL. The distal extension case: An alternative restorative design for implant prosthetics. Int J Periodontics Restorative Dent 2001;21:61–67.	CR	

Table W1 Excluded Full-text Studies by Author and Reasons for Excluding (n = 261*)

Excluded Studies (alphabetical by author)	Exclusion codes	Key table 4
Stellingsma C, Meijer HJ, Raghoebar GM. Use of short endosseous implants and an overdenture in the extremely resorbed mandible: A five-year retrospective study. J Oral Maxillofac Surg 2000;58:382–387.	NC	
Stellingsma K, Bouma J, Stegenga B, Meijer HJ, Raghoebar GM. Satisfaction and psychosocial aspects of patients with an extremely resorbed mandible treated with implant-retained overdentures. A prospective, comparative study. Clin Oral Implants Res 2003;14:166-–172.	L	
Stultz ER, Lofland R, Sendax VI, Hornbuckle C. A multicenter 5-year retrospective survival analysis of 6,200 Integral implants. Compendium 1993;14:478, 480.	P	
Tawil G, Mawla M, Gottlow J. Clinical and radiographic evaluation of the 5-mm diameter regular-platform Brånemark fixture: 2- to 5-year follow-up. Clin Implant Dent Relat Res 2002;4:16–26.	P	
Tawil G, Younan R. Clinical evaluation of short, machined-surface implants followed for 12 to 92 months. Int J Oral Maxillofac Implants 2003;18:894–901.	P	CR
ten Bruggenkate CM, Asikainen P, Foitzik C, Krekeler G, Sutter F. Short (6-mm) nonsubmerged dental implants: Results of a multicenter clinical trial of 1 to 7 years. Int J Oral Maxillofac Implants 1998;13:791–798.	P	
Timmerman R, Stoker GT, Wismeijer D, Oosterveld P, Vermeeren JI, van W. An eight-year follow-up to a randomized clinical trial of participant satisfaction with three types of mandibular implant-retained overdentures. J Dent Res 2004;83:630–633.	OO	
Tolman DE, Laney WR. Tissue-integrated dental prostheses: The first 78 months of experience at the Mayo Clinic. Mayo Clin Proc 1993;68:323–331.	P	
Tolman DE, Laney WR. Tissue-integrated prosthesis complications. Int J Oral Maxillofac Implants 1992;7:477–484.	P	L
Trico J, van Steenberghe D, Rosenberg D, Duchateau L. Implant stability related to insertion torque force and bone density: An in vitro study. J Prosthet Dent 1995;74:608–612.	NH	
Triplett RG, Mason ME, Alfonso WF, McAnear JT. Endosseous cylinder implants in severely atrophic mandibles. Int J Oral Maxillofac Implants 1991;6:264–269.	L	
Truhlar RS, Morris HF, Ochi S. Stability of the bone-implant complex. Results of longitudinal testing to 60 months with the Periotest device on endosseous dental implants. Ann Periodontol 2000;5:42–55.	NC	OO
Vajdovich I, Fazekas A. A ten-year clinical follow-up study of prosthetic rehabilitation of the edentulous lower jaw with endosteal dental implants. J Long Term Eff Med Implants 1999;9:171–183.	P	NT
van Steenberghe D, Quirynen M, Naert I, Maffei G, Jacobs R. Marginal bone loss around implants retaining hinging mandibular overdentures, at 4-, 8- and 12-years follow-up. J Clin Periodontol 2001;28:628–633.	LB	S
van Steenberghe D, Quirynen M, Calberson L, Demanet M. J Head and Neck Pathol 1987;6:53–58.	L	
Vehemente VA, Chuang SK, Daher S, Muftu A, Dodson TB. Risk factors affecting dental implant survival. J Oral Implantol 2002;28:74–81.	P	
Versteegh PA, van Beek GJ, Slagter AP, Ottervanger JP. Clinical evaluation of mandibular overdentures supported by multiple-bar fabrication: A follow-up study of two implant systems. Int J Oral Maxillofac Implants 1995;10:595–603.	LB	
von Wowern N, Gotfredsen K. Implant-supported overdentures, a prevention of bone loss in edentulous mandibles? A 5-year follow-up study. Clin Oral Implants Res 2001;12:19–25.	OO	
Walton JN, MacEntee MI. A prospective study on the maintenance of implant prostheses in private practice. Int J Prosthodont 1997;10:453–458.	L	
Walton JN, MacEntee MI. Problems with prostheses on implants: A retrospective study. J Prosthet Dent 1994;71:283–288.	P	
Walton JN, Huizinga SC, Peck CC. Implant angulation: A measurement technique, implant overdenture maintenance, and the influence of surgical experience. Int J Prosthodont 2001;14:523–530.	L	
Watson CJ, Ogden AR, Tinsley D, Russell JL, Davison EM. A 3- to 6-year study of overdentures supported by hydroxyapatite-coated endosseous dental implants. Int J Prosthodont 1998;11:610–619.	LB	S
Watzek G, Haider R, Mensdorff-Pouilly N, Haas R. Immediate and delayed implantation for complete restoration of the jaw following extraction of all residual teeth: A retrospective study comparing different types of serial immediate implantation. Int J Oral Maxillofac Implants 1995;10:561–567.	I	
Weber HP, Crohin CC, Fiorellini JP. A 5-year prospective clinical and radiographic study of non-submerged dental implants. Clin Oral Implants Res 2000;11:144–153.	P	
Weibrich G, Buch RS, Wegener J, Wagner W. Five-year prospective follow-up report of the Astra tech standard dental implant in clinical treatment. Int J Oral Maxillofac Implants 2001;16:557–562.	P	
Weng D, Jacobson Z, Tarnow D, Hurzeler MB, Faehn O, Sanavi F, Barkvoll P, Stach RM. A prospective multicenter clinical trial of 3i machined-surface implants: Results after 6 years of follow-up. Int J Oral Maxillofac Implants 2003;18:417–423.	P	
Wennerberg A, Carlsson GE, Jemt T. Influence of occlusal factors on treatment outcome: A study of 109 consecutive patients with mandibular implant-supported fixed prostheses opposing maxillary complete dentures. Int J Prosthodont 2001;14:550–555.	NC	
Weyant RJ, Burt BA. An assessment of survival rates and within-patient clustering of failures for endosseous oral implants. J Dent Res 1993;72:2–8.	P	
Wheeler S. Use of the Frialit-2 Implant System in private practice: A clinical report. Int J Oral Maxillofac Implants 2003;18:552–555.	P	

Table W1 Excluded Full-text Studies by Author and Reasons for Excluding (n = 261*)

Excluded Studies (alphabetical by author)	Exclusion codes	Key table 4
Wheeler SL. Eight-year clinical retrospective study of titanium plasma-sprayed and hydroxyapatite-coated cylinder implants. Int J Oral Maxillofac Implants 1996;11:340–350.	P	G
Widmark G, Andersson B, Carlsson GE, Lindvall AM, Ivanoff CJ. Rehabilitation of patients with severely resorbed maxillae by means of implants with or without bone grafts: A 3- to 5-year follow-up clinical report. Int J Oral Maxillofac Implants 2001;16:73–79.	LB	
Willer J, Noack N, Hoffmann J. Survival rate of IMZ implants: A prospective 10-year analysis. J Oral Maxillofac Surg 2003;61:691–695.	P	
Winkler S, Morris HF, Spray JR. Stability of implants and natural teeth as determined by the Periotest over 60 months of function. J Oral Implantol 2001;27:198–203.	OO	
Wismeijer D, Vermeeren JI, van Waas MA. Patient satisfaction with overdentures supported by one-stage TPS implants. Int J Oral Maxillofac Implants 1992;7:51–55.	L	
Wood GD, Hajjar A. A retrospective survey of patients treated with one-stage (ITI) endosseous implants. Dent Update 1997;24:19–23.	P	
Worthington P, Bolender CL, Taylor TD. The Swedish system of osseointegrated implants: Problems and complications encountered during a 4-year trial period. Int J Oral Maxillofac Implants 1987;2:77–84.	P	L
Wright PS, Watson RM, Heath MR. The effects of prefabricated bar design on the success of overdentures stabilized by implants. Int J Oral Maxillofac Implants 1995;10:79–87.	L	
Yusuf H, Ratra N. Observations on 25 patients treated with ball-retained overdentures using the Astra Tech implant system. Eur J Prosthodont Restor Dent 1996;4:181–183.	LB	
Zarb GA, Schmitt A. Implant therapy alternatives for geriatric edentulous patients. Gerodontology 1993;10:28–32.	P	
Zarb GA, Schmitt A. Osseointegration and the edentulous predicament. The 10-year-old Toronto study. Br Dent J 1991;170:439–444.	M	F
Zarb GA, Schmitt A. The edentulous predicament. I: A prospective study of the effectiveness of implant-supported fixed prostheses. J Am Dent Assoc 1996;127:59–65.	M	
Zarb GA, Schmitt A. The edentulous predicament. II: The longitudinal effectiveness of implant-supported overdentures. J Am Dent Assoc 1996;127:66–72.	M	
Zarb GA, Schmitt A. The longitudinal clinical effectiveness of osseointegrated dental implants: The Toronto study. Part I: Surgical results. J Prosthet Dent 1990;63:451–457.	F	
Zarb GA, Schmitt A. The longitudinal clinical effectiveness of osseointegrated dental implants: The Toronto Study. Part II: The prosthetic results. J Prosthet Dent 1990;64:53–61.	M	
Zarb GA, Schmitt A. The longitudinal clinical effectiveness of osseointegrated dental implants: The Toronto study. Part III: Problems and complications encountered. J Prosthet Dent 1990;64:185–194.	M	
Zarb GA, Schmitt A. Osseointegration for elderly patients: The Toronto study. J Prosthet Dent 1994;72:559–568.	P	
Zechner W, Trinkl N, Watzak G, Busenlechner D, Tepper G, Haas R, Watzek G. Radiologic follow-up of peri-implant bone loss around machine-surfaced and rough-surfaced interforaminal implants in the mandible functionally loaded for 3 to 7 years. Int J Oral Maxillofac Implants 2004;19:216–221.	LB	
Zinsli B, Sagesser T, Mericske E, Mericske-Stern R. Clinical evaluation of small-diameter ITI implants: A prospective study. Int J Oral Maxillofac Implants 2004;19:92–99.	P	