Immediate Placement or Immediate Restoration/Loading of Single Implants for Molar Tooth Replacement: A Systematic Review and Meta-analysis

Momen A. Atieh, BDS, MSc[1]/Alan G. T. Payne, BDS, MDent, DDSc, FCD(SA)[2]/
Warwick J. Duncan, BDS, MDS, FRACDS, PhD[3]/
Rohana K. de Silva, BDS, FDSRCPS(Glas), FFDRCS(Ire), FDSRCS(Eng)[4]/
Mary P. Cullinan, BDS, MSc[5]

Purpose: *This systematic review and meta-analysis assessed the survival of immediately placed single implants in fresh molar extraction sites and immediately restored/loaded single molar implants in healed molar sites.* ***Materials and Methods:*** *A search of the main electronic databases, including the Cochrane Oral Health Group's Trials Register, was conducted up to November 1, 2008. The meta-analysis was prepared in accordance with the guidelines of the Academy of Osseointegration Workshop on the State of the Science on Implant Dentistry. The data were analyzed with statistical software.* ***Results:*** *For immediately placed molar implants, nine studies describing 1,013 implants were included to support a survival rate of 99.0%. There were no significant differences between immediate and delayed loading/restoration in molar sites (relative risk of 0.30, 95% confidence interval 0.05 to 1.61; P = .16). For immediate restoration/loading of single implants in healed molar sites, seven studies with 188 single implants were identified. In this case, the implant survival rate was 97.9%, with no difference between immediate and delayed loading (relative risk of 3.0, 95% confidence interval: 0.33 to 27.16; P = .33). Favorable marginal bone level changes in the immediate loading group were detected at 12 months (mean difference of −0.31, 95% confidence interval: −0.53 to −0.096; P = .005).* ***Conclusions:*** *The protocols of immediate placement and immediate restoration/loading of single implants in mandibular molar regions showed encouraging results.* Int J Oral Maxillofac Implants 2010;25:401–415

Key words: *dental implants, immediate loading, immediate placement, immediate restoration, meta-analysis, single implant, systematic review*

[1]PhD Student, Oral Implantology Research Group, Sir John Walsh Research Institute, School of Dentistry, University of Otago, Dunedin, New Zealand.
[2]Associate Professor of Prosthodontics, Oral Implantology Research Group, Sir John Walsh Research Institute, School of Dentistry, University of Otago, Dunedin, New Zealand.
[3]Senior Lecturer in Periodontics, Oral Implantology Research Group, Sir John Walsh Research Institute, School of Dentistry, University of Otago, Dunedin, New Zealand.
[4]Assoociate Professor of Oral and Maxillofacial Surgery, Oral Implantology Research Group, Sir John Walsh Research Institute, School of Dentistry, University of Otago, Dunedin, New Zealand.
[5]Research Associate Professor, Oral Implantology Research Group, Sir John Walsh Research Institute, School of Dentistry, University of Otago, Dunedin, New Zealand.

Correspondence to: Dr Alan Payne, Oral Implantology Research Group, Sir John Walsh Research Institute, School of Dentistry, University of Otago, Dunedin, New Zealand. Fax: +64-3-479-5079. Email: alan.payne@dent.otago.ac.nz

In view of the original conventional approach to the surgical placement of oral implants in edentulous patients,[1] clinicians historically allowed extraction sockets to heal prior to implant placement. Following this, a second procedure was required to place the implant transgingivally[2] or subgingivally[3]; in the latter case, a third surgical appointment was necessary to expose the implant for restoration. These protocols were less technically demanding but subjected patients to multiple surgical interventions. Furthermore, implant loading, regardless of the type of prosthesis, was traditionally delayed until after a conventional healing period to allow for osseointegration. Recently, these traditional protocols for placing and loading oral implants, especially in cases of single tooth replacement, have been revised to meet subjective and objective requirements for fewer surgical interventions and shorter implant treatment times.

Table 1 Definitions of Placement and Loading Protocols[4,19]

Protocol	Definition
Placement	
Immediate placement	Implants placed in fresh extraction sockets (type I)[4]
Delayed placement	Implants placed in healed sites after at least 4 months of healing (type IV)[4]
Loading	
Immediate restoration	Restoration placed within 48 hours of implant placement but not in centric or eccentric occlusal contact with the opposing dentition during healing
Immediate loading	Restoration placed into occlusal load within 48 hours after implant placement
Conventional loading	Restoration placed in a second procedure after a healing period of 3 to 6 months

The term *immediate implant placement* refers to the placement of oral implants at the time of tooth extraction.[4] This protocol offers several advantages, including a reduction in the number of surgical procedures,[5,6] preservation of esthetics and bone height and width,[6,7] improved quality of life, and increased patient comfort and satisfaction.[8] Moreover, the individual healing potential of the fresh extraction socket as well as the implant surface characteristics may provide better opportunities for osseointegration.[5,7,9] With careful patient selection, immediate implant placement, particularly in the esthetic zone of the mouth, has gained acceptance among the scientific community, with several authors showing that success rates can be achieved that are similar to those obtained for delayed implants placed into healed extraction sites.[10–12]

Therefore, immediate implant placement is currently a very popular choice to replace a missing single tooth in the esthetic zone of the mouth.[13] However, the immediate placement of a single implant in molar regions involves numerous challenges related to site-specific anatomic, occlusal, and biomechanical factors. The reported long-term success of oral implants placed in healed maxillary and mandibular molar regions is inferior to that of implants placed in anterior esthetic sites.[14,15] The possibility of predictable outcomes with immediate implantation in molar sites is additionally compromised because of the larger extraction sockets, poor quality of bone (particularly in the maxillary molar regions[16,17]), and less bone apical to the socket because of the proximity of the maxillary sinus or inferior dental canal.[18]

In addition to immediate placement, single implants may also be restored/loaded with an implant-supported prosthesis immediately after placement, with the objectives of shortening treatment time, improving esthetics, and meeting patients' expectations. Immediate loading is defined as placement of a restoration in occlusion within the first 48 hours following surgical implant placement.[19] Furthermore, other authors distinguish between *immediate nonfunctional restoration* and *immediate functional loading*, depending on whether a restoration is placed into occlusion (Table 1).[4,19,20]

Several specific studies have therefore reported high survival rates with immediate restoration/loading or early restoration/loading of single implants in the anterior region, albeit in the short term.[21–25] With recent innovations in implant designs and surface characteristics, immediate loading of oral implants can also be achieved in the posterior regions for short-term periods.[26–30] Several extensive reviews have demonstrated both the effectiveness and the limitations of immediate placement or immediate restoration/loading of oral implants.[31–44]

Although there is a trend to combine the two protocols into immediate placement with immediate loading, the current literature is still reporting either immediate placement or immediate restoration/loading in the molar region. Therefore, it was deemed important to systematically review the placement of single implants in fresh molar extraction sockets and the immediate restoration/loading of single implants placed in healed molar sites in a single paper. The aims of this systematic review were twofold: first, to evaluate the overall effectiveness of single implant placement in fresh molar extraction sockets and, second, to summarize the clinical outcomes of immediate restoration/loading of single implants in healed molar sites.

MATERIALS AND METHODS

This systematic review was conducted according to the guidelines of the Academy of Osseointegration (AO) Workshop on the State of the Science in Implant Dentistry (SSID).[45,46] A PICO format[47] was constructed to identify the objectives and the inclusion criteria. The essential four elements (**P**opulation, **I**ntervention, **C**omparison, **O**utcome) were summarized in the following two questions:

1. Participant: Patients who needed implant placement immediately following extraction of a single molar tooth. Intervention: Immediate implant placement in molar extraction sockets. Comparison: Delayed implant placement in healed molar ridges. Outcome: Implant failure rate.

2. Participant: Patients that needed immediate restoration/loading of a single implant in a healed molar region. Intervention: Immediate implant restoration/loading in healed molar ridges. Comparison: Delayed implant restoration/loading in healed molar ridges. Outcome: Implant failure rate.

Early placement and loading were not included in this review; because the current definition is not clear, it is difficult to compare the outcomes of studies available in the literature.[4,19]

Search Methodology

A comprehensive literature search of the following databases was conducted:

- MEDLINE (1966 through October 2008)
- EMBASE (1980 through October 2008)
- The Cochrane Oral Health Group's Trials Register (up to October 2008)
- The Cochrane Central Register of Controlled Trials (CENTRAL)
- United Kingdom National Research Register
- Australian New Zealand Clinical Trials Registry
- ISI Proceedings for relevant conference abstracts

The search involved human studies reported in any language, with two search strategies being performed. For the first PICO question (regarding the immediate placement of single implants in molar extraction sites), the following combinations of search terms and key words were used: ("immediate placement" OR "immediate implant" OR "immediate implantation") AND ("single implant" OR "single tooth implant" OR "single oral implant") AND ("molar extraction socket" OR molar extraction site") AND ("survival rate" OR "success rate") AND ("randomized controlled clinical trials" OR "controlled clinical trials" OR "prospective" OR "cohort studies" OR "longitudinal" OR "retrospective"). For the second PICO question (regarding the immediate restoration/loading of single implants in healed molar sites), the following combinations of search terms and key words were used: ("immediate loading" OR "immediate restoration") AND ("single implant" OR "single tooth implant" OR "single oral implant") AND ("molar sites" OR "molar regions") AND ("survival rate" OR "success rate") AND ("randomized controlled clinical trials" OR "controlled clinical trials" OR "prospective" OR "cohort studies" OR "longitudinal" OR "retrospective").

Furthermore, bibliographies of the selected articles and relevant reviews were manually searched. A hand search was also conducted in the following journals for the past 5 years (up to November 2008): *Clinical Implant Dentistry and Related Research*, *Clinical Oral Implants Research*, *European Journal of Oral Implantology*, *Implant Dentistry*, *International Journal of Oral & Maxillofacial Implants*, *International Journal of Periodontics & Restorative Dentistry*, *International Journal of Prosthodontics*, *Journal of Clinical Periodontology*, *Journal of Dental Research*, *Journal of Esthetic and Restorative Dentistry*, *Journal of Oral Implantology*, *Journal of Oral Rehabilitation*, *Journal of Periodontal Research*, *Journal of Periodontology*, *Journal of Prosthetic Dentistry*, *Journal of Prosthodontics*, *Oral Surgery Oral Medicine Oral Pathology Oral Radiology and Endodontics*, and *Quintessence International*. In addition, the reviewers attempted to contact corresponding authors, where appropriate, to confirm data extraction and/or obtain missing data.

Study Selection

The searches were carried out by two authors (MA and AP) independently. Any disagreements were resolved by discussion and, if necessary, by a third author (WD). All types of study designs were included, except for case reports because of their lack of quantitative outcomes.[44] In addition, the following inclusion criteria for study selection were considered:

- A minimum of 10 single implants immediately placed or restored/loaded in the maxillary or mandibular molar region
- A mean follow-up period of at least 6 months
- A clearly presented survival or success rate, or available data that allowed calculation of survival or success rate
- The use of endosseous solid root-form titanium oral implants

Implant success and survival were defined according to the broad criteria proposed at the AO workshop to include more studies in the review.[45] Classifications from previous consensus meetings[4,19] were adopted to define placement and loading protocols.

Data Abstraction

The following information was retrieved from the selected studies using a specially designed data template:

- Publication details (title, author(s), journal, year, volume, issue number, pages)

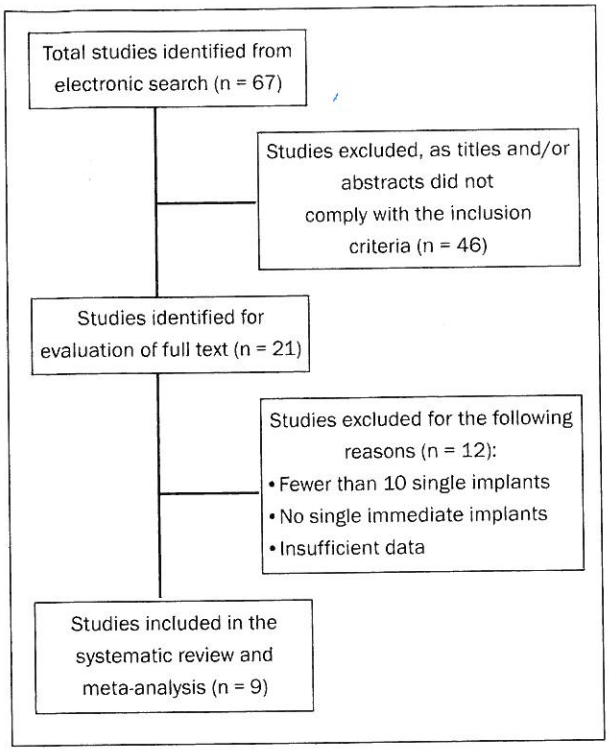

Fig 1 Search strategy for studies related to the immediate placement of single implants in molar extraction sockets.

- Type of study
- Patient details
- Number of implants immediately placed in maxillary or mandibular molar extraction sockets
- Number of implants immediately restored/loaded
- Details of the surgical approach
- Type of bone grafting material, if used
- Implant survival or success rate of treatment group(s)
- Follow-up period

Quality Assessment

Six quality categories[46] were used to evaluate the quality of each selected study according to its design: "fair" for a retrospective study, "average" for a prospective case study, "good" for a prospective study with historical controls, "better" for a prospective study with concurrent controls, "best" for a double-blind randomized controlled trial (RCT), and "unknown" when the study design could not be ascertained or fit none of the definitions.

Statistical Methods

The pooled proportion of implant survival or success was estimated along with the 95% confidence intervals (CIs) using R Statistical Software (version 2.7.1, R Foundation for Statistical Computing). The random-effect pooling model of DerSimonian and Laird[48] was employed for comparison of heterogenous studies. For controlled studies, relative risk and 95% CIs were used to calculate the effect of immediate placement of single implants in fresh molar extraction sockets compared to placement in healed ridges. When heterogeneity was not significant, the Mantel-Haenszel method[49] was used to calculate the fixed-effects pooled relative risks.

The impact of between-study heterogeneity was evaluated using the chi-square test. Because this method has low sensitivity, a P value of $< .1$ was considered indicative of significant heterogeneity.[50] The variation across studies because of heterogeneity was assessed using the I^2 statistic,[51] where an I^2 value of $> 50\%$ was considered significant for the presence of heterogeneity.

RESULTS

Immediate Placement in Extraction Sockets

The initial electronic search identified 67 citations for reviewing. Of these, 46 were rejected after the abstracts were screened. Following the assessment of the full texts of the remaining 21 articles, 12 studies were excluded for the following reasons (Fig 1):

- Three studies were case series with fewer than 10 single implants.[52–54]
- Three studies failed to specify the total number of immediate single implants in molar sites.[55–57]
- Two studies included both single and splinted immediate implants in molar sites; however, the number of single implants was less than 10.[58,59]
- One study failed to report the number of failed single implants in the immediate placement group.[60]
- One study included only two single implants in molar extraction sockets.[61]
- One study compared three different sinus augmentation procedures in conjunction with placement of single implants placed in healed sites.[62]
- One study excluded single implants inserted in molar extraction sockets.[63]

Manual searching did not provide any additional studies. A total of nine studies[64–72] including 1,013 immediate single implants in either maxillary and mandibular molar extraction sockets was included. Contact with the corresponding authors of two studies[71,72] provided additional relevant data and confirmed eligibility for inclusion. The characteristics of the included studies are summarized in Table 2.

Table 2 Characteristics of the Selected Studies on Immediate Placement of Single Implants in Molar Extraction Sockets

Characteristic	Becker and Becker[64]	Bianchi and Sanfilippo[65]	Cafiero et al[66]	Fugazzotto[67]	Fugazzotto[68]	Fugazzotto[69]	Fugazzotto[70]	Levin et al[71]	Peñarrocha et al[72]
Study design	Retrospective	RCT	Prospective	Retrospective	Prospective	Retrospective	Prospective	Retrospective	Retrospective
No. of participants/ implants	22/24; IP: 13, DP: 11	116/42	82/82	319/33	83/83	386/387	320/341	81/81; IP: 21, DP: 60	100/55;IP: 11, DP: 44
Participant age range (y)	48 to 73	19 to 73	21 to 85	24 to 86	38 to 68	28 to 76	26 to 81	18 to 74	20 to 76
Participants' inclusion criteria	Good health; bruxers and clenchers were excluded	Absence of systematic problems, good oral hygiene, stable occlusion, < 15 cigarettes/day, no alcohol or drug dependency	Medically fit, sufficient residual alveolar bone volume, ≥; 2 mm of KT, full-mouth plaque and bleeding scores ≤ 25% at baseline, < 10 cigarettes/d	Absence of systemic conditions, uncontrolled periodontal disease, psychological problems, and radiation therapy in the last 12-mo period	No systemic conditions, chemotherapy, radiation or smoking > 10 cigarettes/d	No systemic conditions, chemotherapy, radiation, or smoking > 10 cigarettes/d	No systemic conditions, chemotherapy, radiation or smoking > 10 cigarettes/d	The presence of adjacent teeth, and follow-up data of 6 mo or more	Healthy patients with sufficient alveolar ridge height and width; smokers were not excluded
Implant system	Brånemark System (machined-surface) (Nobelpharma)	Solid-screw ITI implants (Straumann)	TE ITI implants with SLA surface (Straumann)	IMZ TPS cylindric implants (Biomet/Interpore), TPS threaded ITI implants (Straumann)	TE ITI implants with SLA surface (Straumann)	TE ITI implants with SLA surface (Straumann)	TE ITI implants with SLA surface (Straumann)	Screw-type Core-Vent implants (Zimmer Dental)	Defcon Avantblast-surface implants (Impladent)
Implant diameter (mm)	3.75, 4.0, 5.0	4.1	4.8	3.3, 4.0, 4.25	4.1	4.1, 4.8	4.1, 4.8	≤ 4.0 (n = 24), > 4.0 (n = 57)	5.5
Implant length (mm)	6, 8, 10, 13, 15	10, 12, 14	8, 10, 12, 14	8, 11, 13, 15	11.8	8, 10, 12	8, 10, 12	< 13 (n = 9), ≥ 13 (n = 72)	8.5, 10, 11.5, 13
Implant location	Maxilla, mandible	Maxilla, mandible	Maxilla, mandible	Maxilla, mandible	Maxilla	Maxilla	Mandible	Mandible, maxilla	Mandible, maxilla
Surgical protocol	Mesial-distal luxation followed by gentle removal; implants were placed either into one of the root sockets or into the interradicular bone	Test group: single immediate implants with connective tissue graft (n = 96); control group: single immediate implants without grafts (n = 20)	Full-thickness flap ± releasing incisions, site preparation in the area of interradicular bone, implant anchored in the remaining apical portion of interradicular septum	Atraumatic extraction, socket debridement, residual socket filled with DFDBA, area covered with e-PTFE membrane	Vertical and horizontal releasing incisions, distal wedge incisions for second molars followed by sequential use of osteotome to spread the interradicular bone and lift the sinus	Different flap designs, sectioning of all maxillary molars, removal of each root individually; care to preserve interradicular bone with concomitant regeneration if necessary; tapered osteotomes were used to prepare the interradicular bone	Sulcular incisions with vertical and horizontal releasing incisions, hemisection/trisection of mandibular molars, socket debridement	Atraumatic extraction, socket debrided, sockets prepared with standard drills in interdental bone with maximum use of bone apical to the extraction sockets	Atraumatic extraction, preserving the alveolar bone and interdental papillae

Table 2 Characteristics of the Selected Studies on Immediate Placement of Single Implants in Molar Extraction Sockets, continued

Characteristic	Becker and Becker[64]	Bianchi and Sanfilippo[65]	Cafiero et al[66]	Fugazzotto[67]	Fugazzotto[68]	Fugazzotto[69]	Fugazzotto[70]	Levin et al[71]	Peñarrocha et al[72]
Use of regenerative material	Not clear	Autologous connective tissue graft	Deproteinized bovine bone mineral particles (Bio-Oss, Geistlich) + bioresorbable collagen membrane (Bio-Gide, Geistlich) (gaps > 1.0 mm)	Resorbable TCP (Miter) or DFDBA (Musculoskeletal Foundation) beneath e-PTFE membrane (W.L. Gore)	DFDBA (Exatech) and/or osseous coagulum and bioabsorbable or titanium-reinforced e-PTFE membrane (W.L. Gore) secured with two buccal titanium tacks (Ace Surgical Supply)	HDD > 3 mm were grafted with bovine bone matrix (Osteohealth) or demineralized bone putty impregnated with cortical chips (Exatech); titanium-reinforced or bioabsorbable covering membrane (W.L. Gore) was placed over grafted areas (n = 371)	HDD > 3 mm were grafted with bovine bone matrix (Osteohealth) (n = 165) or demineralized bone putty impregnated with cortical chips (Exatech) (n = 167); titanium-reinforced (n = 269) or bioabsorbable covering membrane (W.L. Gore) was placed over grafted areas (n = 63)	Deproteinized bovine bone mineral particles (Bio-Oss, Geistlich) (reported in only one case)	Dehiscences or HDD > 2 mm were grafted with autologous bone
Use of antibiotics	2 g penicillin or erythromycin 2 h prior to surgery and 1 g daily for 7 d postop	Not clear	Systemic antibiotics (eg, amoxicillin) for 5 d postsurgically	Postoperative antibiotic coverage	500 mg amoxicillin 3× daily for 10 d	500 mg amoxicillin 3× daily for 10 d (erythromycin, 333 mg 3 times daily for 10 d, for amoxicillin-sensitive subjects)	500 mg amoxicillin 3× daily for 10 d (erythromycin, 333 mg 3× daily for 10 d, for amoxicillin-sensitive subjects)	Not clear	Not clear
Time to loading	4–6 mo	3–4 mo	3 mo	Not clear	6 mo	6 mo	3–7 mo	3–6 mo	Not clear
Marginal bone level changes	Not measured	0.75 mm for all groups at 12 mo	−3.2 mm at 12 mo	Not measured	Not measured	Not measured	Not measured	Not clear	IP: 0.83 mm; DP: 0.85 mm
Observation period	24 mo	72 to 108 mo	12	78 to 133 mo	18 mo	40.3 mo	30.8 mo	6 to 125 mo	12 mo
Implant survival rate (%)	IP: 100, DP: 90.9	100	100	93.9*	100†	99.5†	99.1	IP: 100, DP: 90	IP: 100, DP: 90.9†
Quality category	Fair	Better	Average	Fair	Average	Fair	Average	Fair	Fair

DFDBA = demineralized freeze-dried bone allograft; DP = delayed placement; e-PTFE = expanded polytetrafluoroethylene; HDD = horizontal defect dimension; IP = immediate placement; KT = keratinized tissue; RCT = randomized controlled trial; SLA = sandblasted, large-grit, and acid-etched; TCP = tricalcium phosphate; TE = tapered effect; TPS = titanium plasma-spray.
*Success rate (Albrektsson et al[73]); †success rate (Albrektsson et al[74]); ‡success rate (Buser et al[75]).

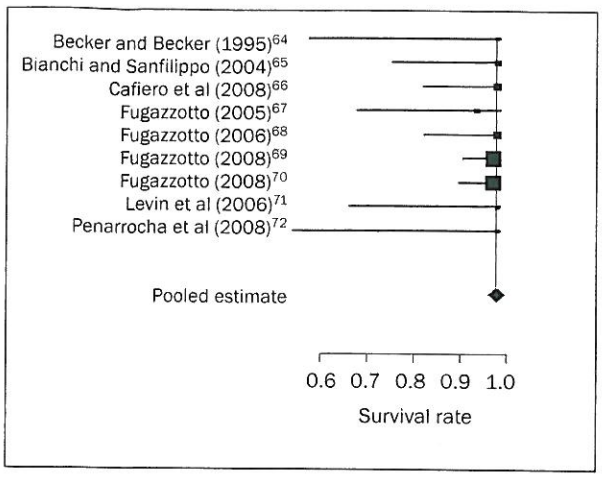

Fig 2 Forest plot analysis of the survival of single implants placed in molar extraction sockets.

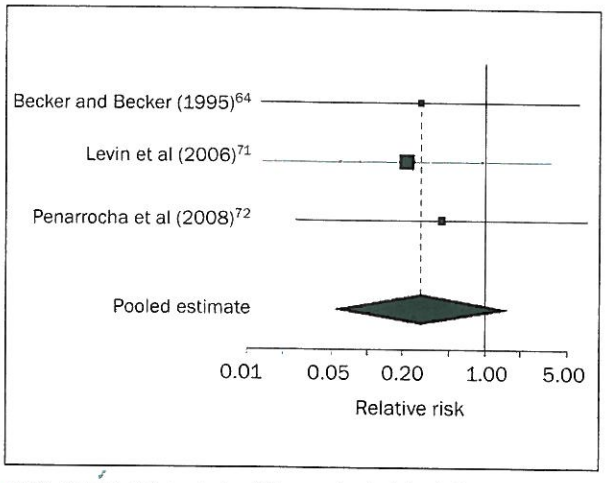

Fig 3 Forest plot analysis of the survival of single implants following immediate placement versus delayed placement in molar sites.

Description of the Included Studies. The main indications for extraction included periodontally or restoratively hopeless molars, root fracture, and endodontic failures.[64,68] All the selected studies excluded patients who had a bruxing/parafunctional habit, systemic diseases, or poor oral hygiene. Heavy smokers (> 10 cigarettes per day) were excluded from all studies but one.[72] In two studies,[66,67] molars with untreated periodontitis were also excluded from the study. Four studies[66,68–70] included in this review used tapered implants with sandblasted and acid-etched surfaces and a shoulder diameter of 6.5 mm. Moreover, most of the studies[66–70,72] included bone augmentation procedures to fill peri-implant voids. The use of preoperative and/or postoperative antibiotics was clearly described by six studies.[64,66–70] The interval before the implants were loaded ranged from 3 months[66] to 7 months.[70]

Quality of the Included Studies. Only one of the included studies was an RCT.[65] However, in this study the randomization was related to the use of connective tissue grafts rather than the time of implant placement. Three studies were categorized as average, as they were prospective case studies without historical or concurrent controls.[66,68,70] The remaining studies were retrospective and were classified as fair.[64,67,69,71,72]

Implant Success/Survival or Failure. All the studies reported the number of failures for implants placed immediately into molar extraction sockets. Three studies[67–69] used criteria published by Albrektsson et al[73,74] to determine the implant success rate, whereas one study[72] defined implant success according to the criteria of Buser et al.[75] The implant survival rates ranged from 93.9%[67] to 100%[64–66,68,71,72] over a period of 12 to 133 months, with an overall pooled estimate of 0.99 (random-effects model, 95% CI: 0.982 to 0.995; Fig 2) in both maxillary and mandibular molar sites. A high degree of statistical homogeneity between studies was detected ($P = 1.0$ with $I^2 = 0\%$).

Only three studies[64,71,72] included separate failure rates for immediately placed single implants and those placed in healed sites; comparable results were reported for the two groups. Similarly, the meta-analysis did not reveal any significant difference between immediate and delayed placement of single implants in molar sites (relative risk of 0.30, 95% CI: 0.05 to 1.61, $P = .16$; Fig 3). No significant statistical heterogeneity was observed between studies ($P = 1.0$ with $I^2 = 0\%$).

Immediate Restoration/Loading in Healed Molar Sites

The electronic search identified 129 articles for further consideration (Fig 4). After the abstracts and key words were screened, 21 studies were regarded as potentially eligible and retrieved for full-text analysis. Fourteen studies were excluded for the following reasons:

- Eight studies did not specify the number of single implants in the molar sites.[27,31,76–81]
- Three studies had molar implants restored with fixed partial dentures.[82–84]
- Two studies reported on early loading in posterior mandibular[85] and maxillary[86] sites.
- One study mentioned molar sites but involved only immediate loading of single implants in premolar areas.[87]

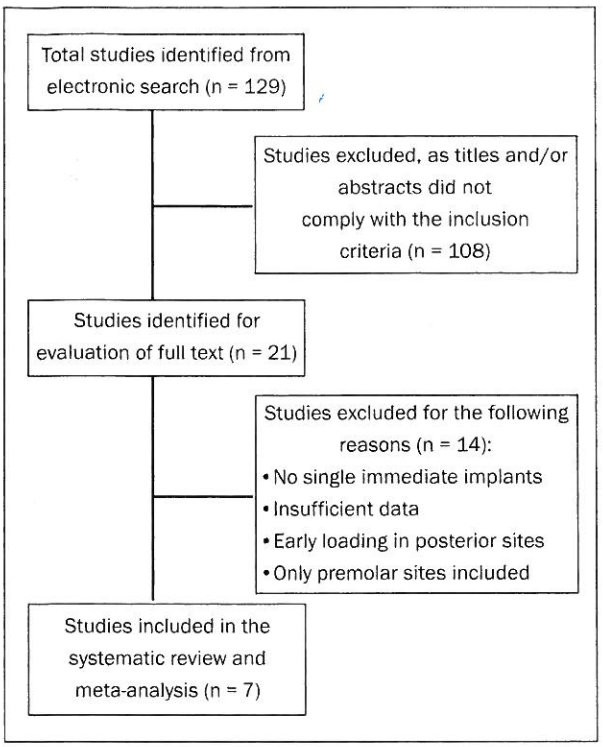

Fig 4 Search strategy for studies related to immediate restoration/loading of single implants in healed molar sites.

No additional relevant studies were identified from the hand search of journals and references. Overall, seven studies[27–29,88–91] with 188 implants in molar sites that had been immediately restored/loaded with single crowns met the inclusion criteria and were included in the analysis (Table 3).

Description of the Included Studies. All the studies[27–29,88–91] applied strict inclusion criteria for selecting participants, which included good general systemic health and adequate bone quality and quantity; smokers, bruxers, and patients with poor oral hygiene were excluded. Sites that required bone augmentation were excluded in two studies.[29,90] Five studies[27,29,89–91] reported immediate loading of single implants with crowns placed in molar sites, while only two[28,88] described the immediate restoration of single implants, also with crowns, in molar sites. Four studies[27,29,89,90] reported on provisional restoration with crowns in occlusion. In one study,[91] lateral excursions were eliminated and the implants were restored in centric relation, while minimal contact in occlusion was maintained in another.[88] Only one study[28] reported an absence of full occlusal contact with the molar crowns in place, hence immediate restoration.

Only one study reported that single implants were placed in healed sites of both maxillary and mandibular molar sites.[88] The remaining studies[27–29,89–91] reported on single implants placed in healed mandibular molar ridges.

Quality of the Included Studies. Two studies[29,91] compared two different loading protocols, namely, immediate versus delayed loading. These studies were identified as RCTs and therefore categorized as better. The remaining studies[27,28,88–90] were prospective case studies without historical or concurrent controls and were classified as average. It is worth noting that the use of a blinded investigator to measure radiographic bone level was featured in only one study.[91]

Implant Success/Survival or Failure with Marginal Bone Level Changes. All the studies reported a high survival rate for immediately restored/loaded single implants in healed molar sites, ranging from 90.9%[88] to 100%[27,28,89] over an observation time of 6 to 36 months. The meta-analysis showed an overall pooled estimate of 0.979 (random-effects model, 95% CI: 0.947 to 0.991; Fig 5). No evidence of statistical heterogeneity was observed ($P = 1.0$ with $I^2 = 0\%$).

Only two studies[29,91] compared implant survival and marginal bone level changes between two different loading protocols, namely immediate and conventional loading. In both studies, single implants were placed in mandibular molar sites and followed up for 12 months; both studies were described as RCTs. One implant failed in the immediate loading group in each study. In one study,[29] no significant differences in marginal bone level changes were observed between the

Table 3 Characteristics of the Selected Studies of Immediate Restoration and/or Loading of Single Implants Placed in Healed Molar Extraction Sockets

Characteristic	Rao and Benzi[27]	Payer et al[28]	Güncü et al[29]	Abboud et al[88]	Calandriello et al[89]	Cornelini et al[90]	Schincaglia et al[91]
Study design	Prospective	Prospective	RCT	Prospective	Prospective	Prospective	RCT
No. of participants/implants	46/51	24/19	IL: 12/12, CL: 12/12	20/11	44/50	30/30	IL: 15/15, CL: 15/15
Participant age range (y)	22–66	29–63	30–55	NS	26–73	27–59	35–68
Participants' inclusion criteria	Good general health, adequate bone width and height; exclusion criteria: bruxers, smokers, ISQ < 65, insertion torque < 30 Ncm,active periodontal or periapical lesion	Good general health, adequate bone width and height; exclusion criteria: bruxers, smokers, questionable patient cooperation	Medically fit patients with bilateral loss of mandibular first molar; exclusion criteria: parafunctional habits, smoking, poor oral hygiene and sites where bone augmentation is needed	Good general systemic health; exclusion criteria: daily smokers, bruxers, and those with uncontrolled periodontitis	Absence of systematic problems, sufficient vertical bone height; bruxers were excluded, but smokers were not excluded	Medically fit, sufficient bone quality; exclusion criteria: parafunctional habits, poor oral hygiene, and sites where bone augmentation is needed	Good general health, adequate bone width and height, no need for bone graft procedures, adequate implant stability, insertion torque ≥ 20 Ncm; smokers were not excluded
Implant system	Replace Select TiUnite (threaded with oxidized surface, tapered body and 1.5 mm-high collar) (Nobel Biocare)	XiVE screw-type implants (Dentsply/ Friadent)	TiUnite MK IV implants, anodized surface (Nobel Biocare)	Ankylos implants (sand-blasted surface with 2-mm smooth transmucosal collar) (Friadent)	TiUnite MK III Wide Platform implants (Nobel Biocare)	ITI solid implants with sandblasted, acid-etched surface (Straumann)	TiUnite MK III Wide-Platform implants (Nobel Biocare)
Implant diameter (mm)	4.3, 5.0, 6.0	3.8, 4.5, 5.5	4.0	3.5, 5.5	5.0	4.1, 4.8	5.0
Implant length (mm)	10, 13	11, 13, 15	11.5	9.5, 11	At least 10	10, 12	8.5, 10, 11.5
Implant location	Mandible	Mandible	Mandible	Maxilla, mandible	Mandible	Mandible	Mandible
Type of occlusion	IL	IR	IL	IR	IL	IL	IL
Marginal bone level changes (mm)	1.12 ± 1.06 (at 12 mo)	0.93 (at 6 mo)	L: 0.45 ± 0.39 (at 12 mo); ICL: 0.68 ± 0.3 (at 12 mo)	0.01 (at 12 mo)	1.3 ± 0.6 (at 12 mo)	0.22 (at 6 mo)	IL: 0.77 ± 0.38 (at 12 mo), CL: 1.2 ± 0.55 (at 12 mo)
Implant stability measurement	ISQ (Osstell) value: 74.1 (at 12 mo)	Periotest value (Siemens): −5 ± 1.2 (at 6 mo)	ISQ values at 12 mo: IL: 75.36 ± 5.88, CL: 75.64 ± 4.84	Periotest value: −4 (at 360 d)	ISQ value: 75 (at 6 mo)	ISQ value: 71.7 ± 6.2 (at 6 mo)	Not measured
Time to definitive restoration	12 wk	24 wk	IL: 1 wk, CL: 12 wk	6 wk	26 wk (for 39 implants), NS (for the remaining 11 implants)	NS	12 wk
Use of antibiotics	No antibiotics were prescribed	Oral antibiotics 1 d before surgery and for 8 d afterward	2 g amoxicillin and clavulanic acid 2 h before surgery and for 4 d afterward	NS	1 g amoxicillin 1 h before surgery and for 3 d afterward	1 g amoxicillin twice daily for 5 d	2 g amoxicillin 2 h before surgery
Follow-up period	12–36 mo	24 mo	12 mo	12 mo	6–12 mo	12 mo	12 mo
Implant survival rate (%)	100	100	IL: 91.7, CL: 100	90.9	100	96.7	IL: 93.3, CL: 100
Quality category	Average	Average	Better	Average	Average	Average	Better

CL = conventional loading; RCT = randomized controlled trial; IL = immediate loading; IR = immediate restoration; ISQ = implant stability quotient; NS = not specified.

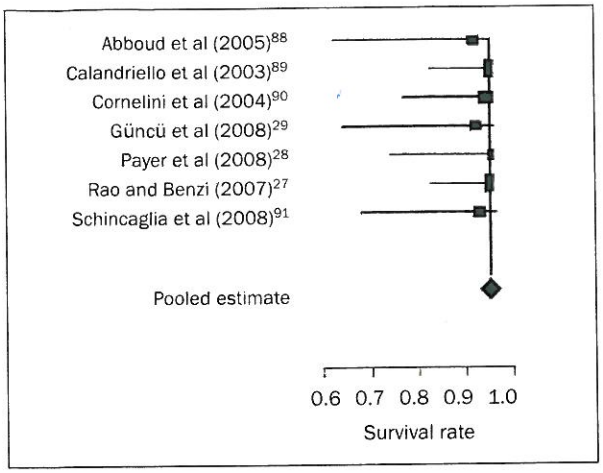

Fig 5 Forest plot analysis of the survival of immediately restored/loaded single implants in healed molar sites.

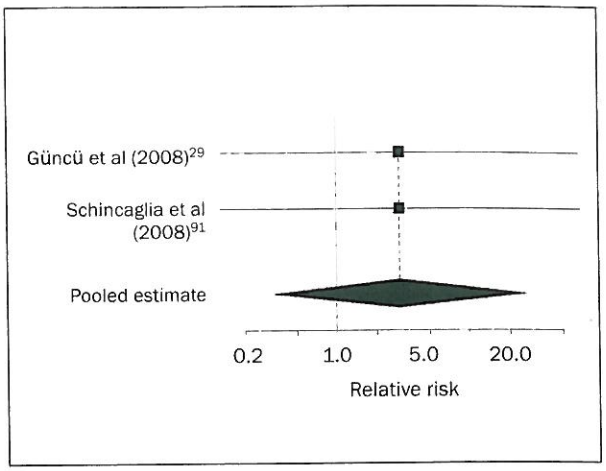

Fig 6 Forest plot analysis of immediate restoration/loading versus conventional loading in healed molar sites: Single implant survival rate.

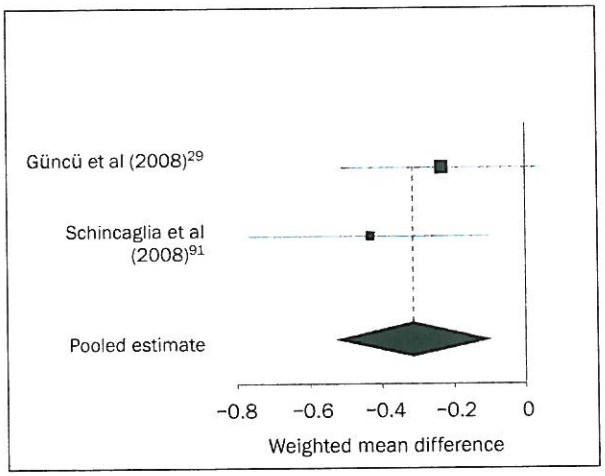

Fig 7 Forest plot analysis of immediate restoration/loading versus conventional loading in healed molar sites: Marginal bone changes after 12 months.

two groups at any point in time, whereas the other study reported significant differences in favor of the immediate loading group.[91]

In terms of implant failure, the meta-analysis found no differences in treatment effect between the immediate and conventional loading groups (relative risk of 3.0, 95% CI: 0.33 to 27.16, $P = .33$, Fig 6). No statistically significant heterogeneity was detected between the studies ($P = 1.0$ with $I^2 = 0\%$). With respect to marginal bone level changes, the meta-analysis revealed a significant difference between the two loading protocols, with a mean difference of −0.31 (95% CI: −0.53 to −0.096, $P = .005$; Fig 7). Despite the inclusion of two trials comparing different loading protocols, no heterogeneity was found among the seven included studies ($P = .37$).

DISCUSSION

The guidelines of the AO SSID workshop[45,46] were followed in conducting this systematic review and meta-analysis. Two PICO questions were formulated. A total of 1,013 single implants placed in fresh molar extraction sites was included in the first analysis to investigate the overall estimate of the survival of immediately placed implants and the corresponding 95% CI. The second analysis included 188 immediately restored/loaded single implants placed into healed molar sites to establish an overall survival rate and its corresponding 95% CI. The pooling of the extracted data in both analyses showed high survival rates: 99.0% for immediate placement and 97.9% for immediate loading of single implants in healed molar sites.

In addition, the meta-analysis showed a statistically similar implant failure rate between immediate and delayed placement of single implants in molar extraction sockets. Likewise, no significant difference in implant failure was found between immediate and delayed implant loading with single crowns in healed molar sites. However, favorable marginal bone level changes were detected after immediate loading of single implants with crowns in healed molar ridges.

It is acknowledged that there are other extensive reviews in the literature evaluating immediate placement and loading.[31–44] Seven review articles[31–37] have specifically discussed the timing of implant placement. The earliest review[31] was a narrative literature review that included both experimental and human studies. It described the importance of placing implants beyond the apex of the tooth socket to achieve primary implant stability and highlighted the need for more investigations to evaluate the use of bone grafting and/or membranes for gap filling. Chen

et al[32] conducted a systematic review to study the histologic basis and clinical outcomes of immediate and delayed implant placement. The search was limited to the MEDLINE electronic database and the bibliographies of relevant articles. All types of study designs, including case series, were identified and included. Meta-analysis was not performed because of the heterogeneity of the included studies. However, comparable short-term survival rates of both immediate and delayed placement were observed. The authors recommended a soft tissue healing period of 4 to 8 weeks before placing implants.

In a Cochrane review,[33] a more comprehensive search strategy was adopted to select all RCTs that examined immediate, immediate-delayed (early), and delayed placement in both partially and completely edentulous situations. Using data from only two RCTs, the reviewers showed that immediate and immediate-delayed placement may offer more advantages in terms of esthetics, alveolar bone height preservation, and patient satisfaction, but the report emphasized the need for more well-designed RCTs to evaluate long-term outcomes. In addition to the broad inclusion criteria, which may have affected the homogeneity of the studies and thus the validity of the meta-analytic results, this review was published in 2006 and has not yet been updated, as is recommended by the Cochrane Collaboration.[92]

As part of the AO workshop in 2006, Quirynen et al[34] published a comprehensive systematic review to study the time of implant placement. The review included all study designs investigating single-tooth and partially and completely edentulous situations. A classification for bone-implant gaps was presented and the recommendation made that bone defects > 2 mm lateral to implants be treated using bone grafts. This review showed an overall failure rate of 4% to 5% when implants were placed in extraction sockets. A higher failure rate was demonstrated with immediate loading of immediately placed implants, particularly for minimally rough-surfaced implants. In addition, the review called for strict inclusion criteria for immediate placement, including proper patient selection and treatment planning. Schropp and Isidor[35] followed a search strategy that included PubMed and a manual search. They reported a summary of clinical guidelines for immediate or early implant placement and considered the combination of immediate implant placement and immediate restoration/loading a viable treatment option in the anterior mandible. However, these authors found limited literature to support these protocols in the maxilla and posterior mandible. Careful patient selection was recommended for replacement of molars, as this was considered a more challenging procedure. Further clinical guidelines and a description of surgical technique for immediate implant placement were presented by Becker and Goldstein.[36] A more recent review[37] discussed in a narrative way the advantages and disadvantages of immediate placement and summarized the most important clinical criteria to achieve a successful outcome.

Specifically regarding loading protocols, seven review papers have also been published.[38–44] Gapski et al[38] conducted a Medline search to critically review and analyze immediate restoration/loading protocols. Primary implant stability was considered the most important requirement for loading. This review discussed the influence of host-, implant-, and occlusion-related factors on the outcome of immediate implant loading. A need for-long term prospective studies to investigate the key factors in successful outcomes and the effect of systemic conditions on immediate loading protocols was emphasized. Attard and Zarb[39] performed an extensive literature review that included all types of studies evaluating immediate or early restoration/loading approaches in partially and completely edentulous patients. Based on 90 studies published between 1975 and 2004, the authors concluded that predictable outcomes can only be achieved in the anterior mandible because of a lack of evidence in the maxilla and posterior mandible. Further long-term studies for separate clinical situations were recommended to allow more meaningful comparisons. Nkenke and Fenner[40] analyzed 38 studies published between 1994 and 2005 and summed up the available literature for immediate restoration/loading in all clinical applications. The authors called for more long-term studies and concluded that there was still no evidence to recommend specific inclusion criteria, implant stability values, and bone quality for successful immediate restoration/loading. Jokstad and Carr[41] conducted a comprehensive systematic review as part of the AO workshop. The review included 22 studies published between 1990 and 2005. The authors showed that the literature lacked a proper methodology and mostly presented short-term results but concluded that immediate and early restoration/loading protocols can result in comparable outcomes to conventional protocols in many clinical situations. Moreover, an updated Cochrane review[42] suggested that immediate and early loading techniques can be realistic alternatives to conventional loading in selected situations. The meta-analysis included 11 RCTs that compared different loading protocols in all clinical situations. No statistically significant differences were found. Although the Cochrane Collaboration's guidelines follow a strict strategy in terms of quality assessment and data analysis, the differences between

partial and complete edentulism in terms of ridge dimensions, occlusal forces, and the presence of teeth may add to the heterogeneity of the included studies and thus compromise the validity of the meta-analytic results. In a more recent review, Henry and Liddelow[43] reviewed the biologic basis and guidelines for immediate loading protocols and presented case reports that included both partially and fully edentulous situations. Sennerby and Gottlow[44] reviewed six controlled studies published after 2005. The authors concluded that immediate and early restoration/loading is a safe and viable alternative in selected cases. It is worth noting that this review revealed no significant differences between machined or moderately rough–surfaced implants following immediate loading. Again, more long-term RCTs were urged.

All the aforementioned review studies have assessed immediate placement and/or immediate restoration/loading of both partial and completely edentulous situations and single-tooth restorations. None of the reviews were limited to single implants or molar sites. The inclusion of such broad criteria made meta-analysis difficult because of the heterogeneity of the studies. In contrast, the present study is different from other previous reviews in many ways. First, the search strategy adopted an extensive approach that included several electronic databases; the Cochrane, United Kingdom, Australian, and New Zealand trials registries; conference proceedings; and abstracts. In addition, the search included a hand search of several journals as well as unpublished and non–English language publications. Second, the authors attempted to answer two focused clinical questions related to placement and loading of single implants in molar areas. Third, the inclusion criteria accepted studies of similar design and quality, permitting the use of a meta-analytic approach and providing answers with a high level of evidence.

However, the authors acknowledge that the present meta-analysis has several limitations. First, the quality of the existing literature was questionable, as most of the included studies were classified as fair or average. Second, the variability in study designs and follow-up periods may have contributed to the heterogeneity among studies. Nevertheless, adequate homogeneity was demonstrated by the close proximity of the boxes to the lines seen on the forest plots, in addition to the test of heterogeneity. Third, of the controlled studies, only three compared immediate placement with other placement protocols, and only two included both immediate and delayed loading groups. Therefore, the inclusion of such a small number of studies might be insufficient to draw solid conclusions. Fourth, few data were available regarding implants in molar sites with respect to other important peri-implant parameters, such as probing pocket depths, probing attachment level, and width of keratinized tissue in molar sites, as a result of limited available data. Finally, the authors' search strategy was not explicitly focused on studies that combined immediate placement of single implants in molar extraction sockets (both maxillary and mandibular) with immediate restoration/loading using a crown. The authors were unable to identify any published controlled clinical trials that compared this treatment option to conventional approaches. Thus, the authors chose to address the question indirectly by conducting simultaneous parallel searches for studies of immediate placement or immediate restoration of implants in molar extraction sockets.

The pooled estimate of the implant survival rate and hence the main findings of the current review showed that immediate placement of single implants in molar extraction sockets and immediate restoration/loading of single implants in healed molar sites are both predictable procedures, provided that strict selection criteria are followed. This review highlights the need for more randomized controlled studies, preferably with long-term outcomes, that include larger numbers of participants to provide further evidence for immediate placement of implants in molar extraction sockets or immediate restoration/loading of single implants in molar sites in healed sites.

CONCLUSIONS

This systematic review and meta-analysis identified nine articles that met inclusion criteria; these demonstrated a high survival rate for single implants immediately placed in molar extraction sockets that was comparable to implant placement in healed sites. Survival rates were also high for immediate restoration/loading of single implants in healed molar sites. The literature currently lacks any controlled studies comparing the combined approach of immediate restoration/loading of immediately placed implants to more traditional implant protocols in molar regions.

REFERENCES

1. Brånemark PI, Hansson BO, Adell R, et al. Osseointegrated implants in the treatment of edentulous jaws. Experience from a 10-year period. Scand J Plast Reconstr Surg Suppl 1977;16:1–132.
2. Schroeder A, Pohler O, Sutter F. Tissue reaction to implant of a titanium hollow cylinder with a titanium surface spray layer. SSO Schweiz Monatsschr Zahnheilkd 1976;86:713–727.
3. Brånemark PI, Adell R, Breine U, Hanson BO, Lindstrom J, Ohlsson A. Intra-osseous anchorage of dental prostheses. I. Experimental studies. Scand J Plast Reconstr Surg 1969;3:81–100.
4. Hämmerle CH, Chen ST, Wilson TG Jr. Consensus statements and recommended clinical procedures regarding the placement of implants in extraction sockets. Int J Oral Maxillofac Implants 2004;19(suppl):26–28.
5. Lazzara RJ. Immediate implant placement into extraction sites: Surgical and restorative advantages. Int J Periodontics Restorative Dent 1989;9:333–343.
6. Werbitt MJ, Goldberg PV. The immediate implant: Bone preservation and bone regeneration. Int J Periodontics Restorative Dent 1992;12:206–217.
7. 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.
8. Rosenquist B, Björn G. Immediate placement of implants into extraction sockets: Implant survival. Int J Oral Maxillofac Implants 1996;11:205–209.
9. Evans CD, Chen ST. Esthetic outcomes of immediate implant placements. Clin Oral Implants Res 2008;19:73–80.
10. Polizzi G, Grunder G, Goené R, et al. Immediate and delayed implant placement into extraction sockets: A 5-year report. Clin Implant Dent Relat Res 2000;2:93–99.
11. West JD, Oates TW. Identification of stability changes for immediately placed dental implants. Int J Oral Maxillofac Implants 2007;22:623–630.
12. Romeo E, Lops D, Rossi A, Storelli S, Rozza R, Chiapasco M. Surgical and prosthetic management of interproximal region with single-implant restorations: 1-year prospective study. J Periodontol 2008;79:1048–1055.
13. Wheeler SL. Implant complications in the esthetic zone. J Oral Maxillofac Surg 2007;65(suppl 1):93–102.
14. Becker W, Becker BE, Alsuwyed A, Al-Mubarak S. Long-term evaluation of 282 implants in maxillary and mandibular molar positions: A prospective study. J Periodontol 1999;70:896–901.
15. Block MS, Gardiner D, Kent JN, Misiek DJ, Finger IM, Guerra L. Hydroxyapatite-coated cylindrical implants in the posterior mandible: 10-year observations. Int J Oral Maxillofac Implants 1996;11:626–633.
16. 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.
17. Bryant SR. The effects of age, jaw site, and bone condition on oral implant outcomes. Int J Prosthodont 1998;11:470–490.
18. Block MS, Kent JN. Placement of endosseous implants into tooth extraction sites. J Oral Maxillofac Surg 1991;49:1269–1276.
19. Cochran DL, Morton D, Weber HP. Consensus statements and recommended clinical procedures regarding loading protocols for endosseous dental implants. Int J Oral Maxillofac Implants 2004;19(suppl):109–113.
20. Degidi M, Piattelli A. Immediate functional and non-functional loading of dental implants: A 2- to 60-month follow-up study of 646 titanium implants. J Periodontol 2003;74:225–241.
21. Ericsson I, Nilson H, Lindh T, Nilner K, Randow K. Immediate functional loading of Brånemark single tooth implants. An 18 months' clinical pilot follow-up study. Clin Oral Implants Res 2000;11:26–33.
22. Lorenzoni M, Pertl C, Zhang K, Wimmer G, Wegscheider WA. Immediate loading single-tooth implants in the anterior maxilla. Preliminary results after one year. Clin Oral Implants Res 2003;14:180–187.
23. Hall JA, Payne AG, Purton DG, Torr B, Duncan WJ, De Silva RK. Immediately restored, single-tapered implants in the anterior maxilla: Prosthodontic and aesthetic outcomes after 1 year. Clin Implant Dent Relat Res 2007;9:34–45.
24. Lang NP, Tonetti MS, Suvan JE, et al. Immediate implant placement with transmucosal healing in areas of aesthetic priority: A multicentre randomized-controlled clinical trial. I. Surgical outcomes. Clin Oral Implants Res 2007;18:188–196.
25. Andersen E, Haanaes HR, Knutsen BM. Immediate loading of single-tooth ITI implants in the anterior maxilla: A prospective 5-year pilot study. Clin Oral Implants Res 2002;13:281–287.
26. Glauser R, Rée A, Lundgren A, Gottlow J, Hämmerle CH, Schärer P. Immediate occlusal loading of Brånemark implants applied in various jawbone regions: A prospective, 1-year clinical study. Clin Implant Dent Relat Res 2001;3:204–213.
27. Rao W, Benzi R. Single mandibular first molar implants with flapless guided surgery and immediate function: Preliminary clinical and radiographic results of prospective study. J Prosthet Dent 2007;97(suppl 6):S3–S14.
28. Payer M, Kirmeier R, Jakse N, Wimmer G, Wegscheider W, Lorenzoni M. Immediate provisional restoration of XiVE screw-type implants in the posterior mandible. Clin Oral Implants Res 2008;19:160–165.
29. Güncü MB, Aslan Y, Tümer C, Güncü GN, Uysal S. In-patient comparison of immediate and conventional loaded implants in mandibular molar sites within 12 months. Clin Oral Implants Res 2008;19:335–341.
30. Zöllner A, Ganeles J, Korostoff J, Guerra F, Krafft T, Brägger U. Immediate and early non-occlusal loading of Straumann implants with a chemically modified surface (SLActive) in the posterior mandible and maxilla: Interim results from a prospective multicenter randomized-controlled study. Clin Oral Implants Res 2008;19:442–450.
31. Schwartz-Arad D, Chaushu G. The ways and wherefores of immediate placement of implants into fresh extraction sites: A literature review. J Periodontol 1997;68:915–923.
32. Chen ST, Wilson TG Jr, Hämmerle CHF. Immediate or early placement of implants following tooth extraction: Review of biologic basis, clinical procedures, and outcomes. Int J Oral Maxillofac Implants 2004;19(suppl):12–25.
33. Esposito MA, Koukoulopoulou A, Coulthard P, Worthington HV. Interventions for replacing missing teeth: Dental implants in fresh extraction sockets (immediate, immediate-delayed and delayed implants). Cochrane Database Syst Rev 2006;4:CD005968.
34. Quirynen M, Van Assche N, Botticelli D, Berglundh T. How does the timing of implant placement to extraction affect outcome? Int J Oral Maxillofac Implants 2007;22(suppl):203–223.
35. Schropp L, Isidor F. Timing of implant placement relative to tooth extraction. J Oral Rehabil 2008;35(suppl 1):33–43.
36. Becker W, Goldstein M. Immediate implant placement: Treatment planning and surgical steps for successful outcome. Periodontol 2000 2008;47:79–89.

37. Bhola M, Neely AL, Kolhatkar S. Immediate implant placement: Clinical decisions, advantages, and disadvantages. J Prosthodont 2008;17:576–581.
38. Gapski R, Wang HL, Mascarenhas P, Lang NP. Critical review of immediate implant loading. Clin Oral Implants Res 2003;14: 512–527.
39. Attard NJ, Zarb GA. Immediate and early implant loading protocols: A literature review of clinical studies. J Prosthet Dent 2005;94:242–258.
40. Nkenke E, Fenner M. Indications for immediate loading of implants and implant success. Clin Oral Implants Res 2006; 17(suppl 2):19–34.
41. Jokstad A, Carr AB. What is the effect on outcomes of time-to-loading of a fixed or removable prosthesis placed on implant(s)? Int J Oral Maxillofac Implants 2007;22(suppl): 19–48.
42. Esposito M, Grusovin MG, Willings M, Coulthard P, Worthington HV. Interventions for replacing missing teeth: Different times for loading dental implants. Cochrane Database Syst Rev 2007;2:CD003878.
43. Henry PJ, Liddelow GJ. Immediate loading of dental implants. Aust Dent J 2008;53(suppl 1):S69–S81.
44. Sennerby L, Gottlow J. Clinical outcomes of immediate/early loading of dental implants. A literature review of recent controlled prospective clinical studies. Aust Dent J 2008;53 (suppl 1):S82–S88.
45. Iacono VJ, Cochran DL. State of the science on implant dentistry: A workshop developed using an evidence-based approach. Int J Oral Maxillofac Implants 2007;22(suppl):7–10.
46. Proskin HM, Jeffcoat RL, Catlin A, Campbell J, Jeffcoat MK. A meta-analytic approach to determine the state of the science on implant dentistry. Int J Oral Maxillofac Implants 2007; 22(suppl):11–18.
47. Needleman I. Introduction to evidence-based dentistry. In: Clarkson J, Harrison JE, Ismail AI, Needleman I, Worthington HV (eds). Evidence-Based Dentistry for Effective Practice. London: Taylor & Francis, 2002:7–10.
48. DerSimonian R, Laird N. Meta-analysis in clinical trials. Control Clin Trials 1986;7:177–188.
49. Mantel N, Haenszel W. Statistical aspects of the analysis of data from retrospective studies of disease. J Natl Cancer Inst 1959 ;22:719–748.
50. Lau J, Ioannidis JP, Schmid CH. Quantitative synthesis in systematic reviews. Ann Intern Med 1997;127:820–826.
51. Higgins JP, Thompson SG. Quantifying heterogeneity in a meta-analysis. Stat Med 2002;21:1539–1558.
52. Zubery Y. Immediate implants without primary stabilization in the molar region. Refuat Hapeh Vehashinayim 2001;18:47–51.
53. Vergara JA, Caffesse RG. Immediate replacement of single upper posterior teeth: A report of cases. Clin Implant Dent Relat Res 2003;5:130–136.
54. Doobrow JH, Leite RS, Hirsch HZ. Concomitant oroantral communication repair and immediate implant placement: A five-year case report. Implant Dent 2008;17:176–181.
55. Grunder U, Polizzi G, Goené R, et al. A 3-year prospective multicenter follow-up report on the immediate and delayed-immediate placement of the implants. Int J Oral Maxillofac Implants 1999;14:210–216.
56. Prosper L, Gherlone EF, Redaelli S, Quaranta M. Four-year follow-up of larger-diameter implants placed in fresh extraction sockets using a resorbable membrane or resorbable alloplastic material. Int J Oral Maxillofac Implants 2003;18:856–864.
57. Wagenberg B, Froum SJ. A retrospective study of 1,925 consecutively placed immediate implants from 1988 to 2004. Int J Oral Maxillofac Implants 2006;21:71–80.
58. Schwartz-Arad D, Grossman Y, Chaushu G. The clinical effectiveness of implants placed immediately into fresh extraction sites of molar teeth. J Periodontol 2000;71:839–844.
59. Artzi Z, Parson A, Nemcovsky CE. Wide-diameter implant placement and internal sinus membrane elevation in the immediate postextraction phase: Clinical and radiographic observations in 12 consecutive molar sites. Int J Oral Maxillofac Implants 2003;18:242–249.
60. Levine RA, Ganeles J, Jaffin RA, Clem DS III, Beagle JR, Keller GW. Multicenter retrospective analysis of wide-neck dental implants for single molar replacement. Int J Oral Maxillofac Implants 2007;22:736–742.
61. Gomez-Roman G, Kruppenbacher M, Weber H, Schulte W. Immediate postextraction implant placement with root-analog stepped implants: Surgical procedure and statistical outcome after 6 years. Int J Oral Maxillofac Implants 2001;16:503–513.
62. Jurisic M, Markovic A, Radulovic M, Brkovic BM, Sándor GK. Maxillary sinus floor augmentation: Comparing osteotome with lateral window immediate and delayed implant placements. An interim report. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2008;106:820–827.
63. Misch CE, Misch-Dietsh F, Silc J, Barboza E, Cianciola LJ, Kazor C. Posterior implant single-tooth replacement and status of adjacent teeth during a 10-year period: A retrospective report. J Periodontol 2008;79:2378–2382.
64. Becker W, Becker BE. Replacement of maxillary and mandibular molars with single endosseous implant restorations: A retrospective study. J Prosthet Dent 1995;74:51–55.
65. Bianchi AF, Sanfilippo F. Single-tooth replacement by immediate implant and connective tissue graft: A 1–9-year clinical evaluation. Clin Oral Implants Res 2004;15:269–277.
66. Cafiero C, Annibali S, Gherlone E, et al. Immediate transmucosal implant placement in molar extraction sites: A 12-month prospective multicenter cohort study. Clin Oral Implants Res 2008;19:476–482.
67. Fugazzotto PA. Success and failure rates of osseointegrated implants in function in regenerated bone for 72 to 133 months. Int J Oral Maxillofac Implants 2005;20:77–83.
68. Fugazzotto PA. Implant placement at the time of maxillary molar extraction: Technique and report of preliminary results of 83 sites. J Periodontol 2006;77:302–309.
69. Fugazzotto PA. Implant placement at the time of maxillary molar extraction: Treatment protocols and report of results. J Periodontol 2008;79:216–223.
70. Fugazzotto PA. Implant placement at the time of mandibular molar extraction: Description of technique and preliminary results of 341 cases. J Periodontol 2008;79:737–747.
71. Levin L, Laviv A, Schwartz-Arad D. Long-term success of implants replacing a single molar. J Periodontol 2006;77: 1528–1532.
72. Peñarrocha-Diago M, Carrillo-Garcia C, Boronat-Lopez A, García-Mira B. Comparative study of wide-diameter implants placed after dental extraction and implants positioned in mature bone for molar replacement. Int J Oral Maxillofac Implants 2008;23:497–501.
73. Albrektsson T, Zarb GA. Current interpretations of the osseointegrated response: Clinical significance. Int J Prosthodont 1993;6:95–102.
74. Albrektsson T, Zarb G, Worthington P, Eriksson AR. The long-term efficacy of currently used dental implants. A review and proposed criteria of success. Int J Oral Maxillofac Implants 1986;1:11–25.
75. Buser D, Mericske-Stern R, Dula K, Lang NP. Clinical experience with one-stage, non-submerged dental implants. Adv Dent Res 1999;13:153–161.

76. Calandriello R, Tomatis M, Rangert B. Immediate functional loading of Brånemark system implants with enhanced initial stability: A prospective 1- to 2-year clinical and radiographic study. Clin Implant Dent Relat Res 2003;5(suppl 1):10–20.
77. Rocci A, Martignoni M, Gottlow J. Immediate loading in the maxilla using flapless surgery, implants placed in predetermined positions, and prefabricated provisional restorations: A retrospective 3-year clinical study. Clin Implant Dent Relat Res 2003;5(suppl 1):29–36.
78. Testori T, Del Fabbro M, Feldman S, et al. A multicenter prospective evaluation of 2-months loaded Osseotite implants placed in the posterior jaws: 3-year follow-up results. Clin Oral Implants Res 2002;13:154–161.
79. Glauser R, Lundgren AK, Gottlow J, et al. Immediate occlusal loading of Brånemark TiUnite implants placed predominantly in soft bone: 1-year results of a prospective clinical study. Clin Implant Dent Relat Res 2003;5(suppl 1):47–56.
80. Galli F, Capelli M, Zuffetti F, Testori T, Esposito M. Immediate non-occlusal vs early loading of dental implants in partially edentulous patients: A multicentre randomized clinical trial. Peri-implant bone and soft tissue levels. Clin Oral Implants Res 2008;19:546–552.
81. Ganeles J, Zöllner A, Jackowski J, ten Bruggenkate C, Beagle J, Guerra F. Immediate and early loading of Straumann implants with a chemically modified surface (SLActive) in the posterior mandible and maxilla: 1-year results from a prospective multicenter study. Clin Oral Implants Res 2008;12:1119–1128.
82. Nikellis I, Levi A, Nicolopoulos C. Immediate loading of 190 endosseous dental implants: A prospective observational study of 40 patient treatments with up to 2-year data. Int J Oral Maxillofac Implants 2004;19:116–123.
83. Rocci A, Martignoni M, Gottlow J. Immediate loading of Brånemark system TiUnite and machined-surface implants in the posterior mandible: A randomized open-ended clinical trial. Clin Implant Dent Relat Res 2003;5(suppl 1):57–63.
84. Achilli A, Tura F, Euwe E. Immediate/early function with tapered implants supporting maxillary and mandibular posterior fixed partial dentures: Preliminary results of a prospective multicenter study. J Prosthet Dent 2007;97(suppl 6):S52–S58.
85. Salvi GE, Gallini G, Lang NP. Early loading (2 or 6 weeks) of sandblasted and acid-etched (SLA) ITI implants in the posterior mandible. A 1-year randomized controlled clinical trial. Clin Oral Implants Res 2004;15:142–149.
86. Roccuzzo M, Wilson T. A prospective study evaluating a protocol for 6 weeks' loading of SLA implants in the posterior maxilla: One year results. Clin Oral Implants Res 2002;13:502–507.
87. Proussaefs P, Lozada J. Immediate loading of hydroxyapatite-coated implants in the maxillary premolar area: Three-year results of a pilot study. J Prosthet Dent 2004;91:228–233.
88. Abboud M, Koeck B, Stark H, Wahl G, Paillon R. Immediate loading of single-tooth implants in the posterior region. Int J Oral Maxillofac Implants 2005;20:61–68.
89. Calandriello R, Tomatis M, Vallone R, Rangert B, Gottlow J. Immediate occlusal loading of single lower molars using Brånemark system wide-platform TiUnite implants: An interim report of a prospective open-ended clinical multicenter study. Clin Implant Dent Relat Res 2003;5(suppl 1):74–80.
90. Cornelini R, Cangini F, Covani U, Barone A, Buser D. Immediate restoration of single-tooth implants in mandibular molar sites: A 12-month preliminary report. Int J Oral Maxillofac Implants 2004;19:855–860.
91. Schincaglia GP, Marzola R, Giovanni GF, Chiara CS, Scotti R. Replacement of mandibular molars with single-unit restorations supported by wide-body implants: Immediate versus delayed loading. A randomized controlled study. Int J Oral Maxillofac Implants 2008;23:474–480.
92. Higgins JPT, Green S (eds). Cochrane Handbook for Systematic Reviews of Interventions Version 5.0.0. The Cochrane Collaboration, 2008. Available at www.cochrane-handbook.org. Accessed 5 January 2010.