How Does the Timing of Implant Placement to Extraction Affect Outcome?

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Purpose: *To systematically review the current literature on the clinical outcomes and incidence of complications associated with immediate implants (implants placed into extraction sockets at the same surgery that the tooth is removed) and early implants (implants placed following soft tissue healing).* ***Materials and Methods:*** *A MEDLINE search was conducted for English papers on immediate/early placement of implants based on a series of search terms. Prospective as well as retrospective studies (randomized/nonrandomized clinical trials, cohort studies, case control studies, and case reports) were considered, as long as the follow-up period was at least 1 year of loading and at least 8 patients and/or at least 10 implants had been examined. Screening and data abstraction were performed independently by 3 reviewers. The types of complications assessed were implant loss; marginal bone loss; soft tissue complications, including peri-implantitis; and esthetics.* ***Results:*** *The initial search provided 351 abstracts, of which 146 were selected for full-text analysis. Finally, 17 prospective and 17 retrospective studies were identified, with observation times generally between 1 and 2 years for the prospective studies and around 5 years for the retrospective studies. The heterogeneity of the studies (including postextraction defect characteristics, surgical technique with or without membrane and/or bone substitute, implant location in socket, inclusion and exclusion criteria, and prosthetic rehabilitation), however, rendered a meta-analysis impossible. Most papers contained only data on implant loss and did not provide useful information on failing implants or on hard and soft tissue changes. In general, the implant loss remained below 5% for both immediate and early placed implants (range, 0% to 40% for immediate implants and 0% to 9% for early placed implants), with a tendency toward higher losses when implants were also immediately loaded.* ***Conclusion:*** *Because of the lack of long-term data, questions regarding whether peri-implant health, prosthesis stability, degree of bone loss, and esthetic outcome of immediate or early placed implants are comparable with implants placed in healed sites remain unanswered.* Int J Oral Maxillofac Implants 2007;22(suppl): 203–223

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Osseointegration has provided treatment opportunities which have revolutionized the rehabilitation of body part losses such as edentulism. The ability to rehabilitate predictably completely and partially edentulous patients has been demonstrated.[1–4] Traditional guidelines suggested that 2 to 3 months of alveolar ridge remodeling following tooth extraction and an additional 3 to 6 months of load-free healing after implant insertion were needed for osseointegration to take place.[5–7] This extended treatment period and the need for a removable prosthesis during the healing phase may be inconvenient to certain patients.

The placement of implants into fresh extraction sockets was introduced in the late 1970s.[8] This approach has been reviewed extensively during the last decade[2,9–11] and seems promising. Several recent papers have presented clear clinical guidelines for patient selection and/or for an optimal outcome.[9,12–16]

Placement of an implant immediately after tooth extraction seems to offer several advantages and nearly no disadvantages when compared to the tra-

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Table 1 Global Comparison Between Immediate, Early, and Delayed Implant Insertion

	Immediate	Early	Delayed
Time	Short treatment time	Short treatment time	Long treatment time
Surgery	Reduced number of surgical procedures Bone substitute to fill in voids where applicable Use of membrane may be indicated	Extra surgical intervention Bone substitute to fill in voids where applicable Use of membrane may be indicated	Extra surgical intervention Reduced number of cases in need of bone substitute Membrane less frequently needed
Antibiotics	Recommended	Often recommended	Not always necessary
Implant position	Do not allow socket to dictate implant position	Do not allow socket to dictate implant position	
Bone	Less resorption buccal bone plate? Increased osteoblast activity up to week 8	Less resorption buccal bone plate? Increased osteoblast activity up to week 8	Obvious resorption buccal bone plate
Special requirements	Primary stability is to be achieved via apical/lateral stabilization Ability to remove all residual infection	Primary stability is to be achieved via apical/lateral stabilization	
Outcome	Implant survival data seem similar for the 3 groups; data on implant success are sparse for immediate and early placement		

ditional approaches (Table 1). The social and economic impact of a reduction in number of surgeries and in treatment time is evident. Other aspects, such as implant success, esthetic outcome, preservation of alveolar process, impact of remaining infection, and the use of membranes and/or bone substitutes, however, are still topics of debate.

The present review deals with the clinical outcome of immediate and early implant placement in humans and illustrates the heterogeneity between studies. Guidelines for future reports are suggested.

Healing of Extraction Socket and Impact of Early Implant Placement

Both animal experiments and clinical studies have revealed that the alveolar ridge undergoes dimensional alterations in both horizontal and vertical directions after tooth extraction. The extraction of multiple teeth results in an overall diminution of the size of the edentulous ridge.[17–22] Even the extraction of a single tooth leads to marked hard and soft tissue alterations. Schropp and coworkers[23] studied the alveolar ridge alterations following single premolar and molar extraction in 46 patients. While the vertical changes were negligible, the horizontal resorption amounted to about 30% at 3 months and 50% of the width of the ridge at 12 months after tooth extraction. A median buccolingual ridge reduction of 5.9 mm (25th and 75th percentiles of 4.7 and 7.7 mm, respectively) was found. These changes were slightly greater in molar sites than in premolar sites and in the mandible when compared with the maxilla. Similar observations were made by Camargo and coworkers[24] and Iasella and coworkers.[25] They followed the healing of nonmolar extraction sites for 4 to 6 months and recorded a horizontal ridge width reduction of 3.1 mm (SD 2.4 mm) and 2.6 mm (SD 2.3 mm), respectively.

A recent histological analysis in dogs[26,27] clearly illustrated, as suggested some decades ago,[28–30] that bone resorption after tooth extraction was more pronounced at the buccal than at the lingual aspect of the socket walls. The immediate placement of implants has been suggested as a way to minimize this resorption. Recent clinical studies, however, have indicated that these ridge alterations also occur when implants are placed in fresh extraction sockets. Botticelli and associates[30] placed 21 implants in the fresh extraction sockets of 18 patients. During a reentry procedure at 4 months healing they recorded, with the implant as reference, a horizontal resorption of about 50% at the buccal aspect and 30% at the lingual side of the implant, corresponding to an overall horizontal width reduction of 2.8 mm, reducing the jawbone width from 10.5 mm to 7.8 mm. Covani and coworkers[31] also observed that immediate implant placement could not prevent resorption in the buccolingual direction of the alveolar process.

These findings were further confirmed in experimental studies in dogs.[26,27,32] Botticelli and coworkers[32] recently observed that the aforementioned bone resorption depended on the presence and periodontal health of the neighboring teeth. At sites where teeth with an intact periodontium are present mesial and distal of the extraction socket, the height of the proximal socket walls may be retained after immediate implant placement, and the horizontal

reduction of the crestal bone may be limited to the buccal walls of the recipient site.

The results from these recent clinical and experimental studies suggest that when clinicians operate in the esthetic zone it may be reasonable to allow soft and hard tissue healing before implant surgery to be able to compensate for the resorption at the buccal site, or as an alternative place hard or soft tissue grafts with the implant. When an implant is placed in a fresh extraction socket, it seems prudent to place it in the lingual/palatal portion of the socket, with its marginal border well below the ridge of the fresh socket to compensate for the expected resorption. However, more long-term clinical data are needed to further support these guidelines and to evaluate the impact of such treatment strategies on long-term implant success (including aspects such as marginal bone and soft tissue stability and esthetics).

The Socket as a Guide for Implant Positioning

Several papers have indicated the advantage of using the socket as guide for the surgeon during immediate implant placement. However, as the clinician begins to prepare the osteotomy site, the cutting bur will often "walk down" the axial wall of the socket, coming to rest at the position previously occupied by the apex of the extracted tooth. If this "walking maneuver" is not prevented (eg, via special instruments), the residual extraction socket morphology, including the slope of the axial walls of the extraction socket, root dilacerations, and the position of the previous root apex, may result in a prosthetically undesirable buccal implant angulation and/or location.

A unique challenge is often present when implant placement in the maxillary first premolar fresh extraction socket is contemplated. The residual interradicular bone might encumber the clinician in attempts to idealize the buccopalatal location of site preparation and subsequent implant placement. If site preparation is begun buccal to the interradicular septum, the final implant position is often too far buccal, resulting in an unesthetic final restoration. If site preparation begins palatal to the residual interradicular septum, the palatal implant positioning necessitates fabrication of a ridge-lapped crown and creates a potential plaque control problem.[33]

Pathology of the Remaining Bone

Often, a tooth is extracted because of infection of either endodontic or periodontal origin. After removal of the tooth, residual infection at the extraction site may endanger the osseointegration. In general a series of papers illustrates that immediate implants in an infected socket (endodontic pathology) are not really at risk. One should take into account that several authors base this statement on a case report,[34] a retrospective clinical trial,[35] and 2 animal studies.[36,37] In addition, the degree to which a socket is debrided prior to implant placement needs to be determined. On the other hand, both implant loss as well as the occurrence of a periapical lesion on implants have recently been clearly linked to a history of endodontic or periapical pathology of the extracted tooth.[38,39]

Other papers reported slightly higher failure rates for immediate implants placed in periodontitis patients,[40–42] even though animal studies could not show a clear difference between implants placed in sites with a history of periodontal inflammation and healthy sites.[37,43,44] It is therefore reasonable to state that there is currently a lack of definitive evidence regarding the effect of residual local pathology on the success and survival of immediate implants.

Immediate Implant Placement in Growing Children

Immediate implant placement might be considered a useful treatment option for young adolescents who have lost a maxillary incisor secondary to trauma. Osseointegrated oral implants, like ankylosed teeth, however, do not participate in changes within the jawbones (displacement, remodeling, mesial drift). Facial growth of the child, even in adolescence, as well as the continuous eruption of the adjacent anterior teeth, are significant risk factors, especially when esthetics and function are considered (for review, see Op Heij and colleagues[45,46]). For patients with a normal facial profile, the placement of an implant, especially in the esthetic zone, should at least be postponed until growth cessation. For patients with a short- or long-face type/syndrome, further growth, especially the continuous eruption of adjacent teeth, could create a risk even after the age of 20 years, as illustrated by some recent clinical studies.[47,48]

MATERIALS AND METHODS

Search Strategy

A thorough MEDLINE search of the English literature was carried out by the Academy of Osseointegration in 2005 using the term "implants." All retrieved abstracts/titles were analyzed by 2 independent reviewers who selected all studies with potentially useful data (eg, human studies, clinical data, 1-year follow-up) for the 8 PICO questions (Patient, Intervention, Comparison, Outcome) for the Academy of Osseointegration's State of the Science on Implant Dentistry workshop in 2006. The search resulted in more than 1,800 electronic abstracts/titles.

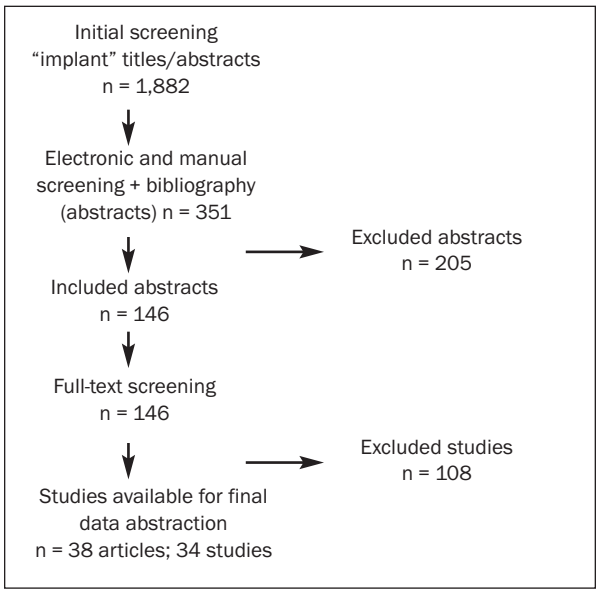


Fig 1 Flow of papers during the review process.

These abstracts/titles were further explored electronically, for this systematic review, using the search terms "immediate," "immediately," "direct," "early," "simultaneous," "fresh" (extraction sites), "extraction," "extracted," "after loss of teeth." An additional PubMed search was conducted, and work published until May 2005 was included. The search term "dental/oral implants" was used in combination with "cohort studies," "case control studies," "immediate placement," "delayed placement," "early placement," or "extraction." The inclusion criteria were the use of human subjects and the presence of clinical data. Finally, manual searches were performed based on bibliographies of previous reviews and the references in the selected papers, as well as in the following journals: *Clinical Implant Dentistry & Related Research*, *Clinical Oral Implants Research*, *International Journal of Oral & Maxillofacial Implants*, *International Journal of Periodontics & Restorative Dentistry*, *Journal of Clinical Periodontology,* and *Journal of Periodontology*. This first screening resulted in a collection of 351 potentially useful abstracts (Fig 1).

Study Inclusion Criteria. This review included papers on studies of patients with single-tooth, partial, or full edentulism treated with or without simultaneous guided bone regeneration. Only studies using conventional root-form endosseous implants were considered; mini implants were excluded. Prospective and retrospective studies (randomized and nonrandomized clinical trials, cohort studies, case control studies, or case reports) were considered if follow-up (under loading) of at least 1 year had been conducted for at least 80% of the implants. If it was not evident from the paper that the study was prospective, the paper was classified as retrospective. Case reports were only included if at least 8 patients or 10 implants were enrolled.

Outcome Variables

Even though the impact of the implant-based rehabilitation on the quality of a patient's life should be the primary outcome variable tested, this review could only retrieve data on an implant/prosthesis level (with the exception of 1 paper[49]). The following variables have been included in the review process:

- *Implant loss.* For this parameter the criteria of each paper have been respected. An evaluation of implant immobility (as assessed on individual implants) or absence of peri-implant radiolucency (assessed on radiographs)—standard criteria of proper osseointegration—was not always available. A distinction was made between implants lost or removed before the prosthetic restoration (regarded as early loss) and those lost or removed afterward (called late failures), with the exception of fractured implants.
- *Crestal bone loss.* The degree of marginal bone loss during implant loading was also considered. The phrase "no data" (ND) was used to indicate that a study lacked radiographic examination (Tables 2 and 3). If data from radiographic examinations were presented as mean values but no frequency distributions were provided, the study was scored as NR "not reported" for this parameter.
- *Peri-implantitis.* The frequency of implants exhibiting symptoms of peri-implantitis according to the definitions created by Albrektsson and Isidor[81] was also recorded. Implants demonstrating probing depth of > 6 mm in combination with bleeding on probing/suppuration and attachment loss/bone loss of 2.5 mm in 5 years were considered to exhibit peri-implantitis.[2] In addition to the direct information on peri-implantitis, results regarding probing and attachment level assessments were also analyzed. Lack of probing data for all implants was indicated with the letters ND (Tables 2 and 3). If probing data were presented in terms of mean values but no frequency distributions were provided, the data were classified as NR.
- *Soft tissue complications.* Symptoms from the peri-implant tissues, such as persisting pain, excessive swelling, hyperplasia requiring surgical therapy, fistula formation, or suppuration, were regarded as complications and presented as such. Data on the gingival margin (gingival recession) were also examined (Tables 2 and 3).

Table 2 Implant Loss and Complications for Immediate and Early Placed Implants as Reported in Prospective Studies (in Alphabetic Order)

References	n impl / n pat	Implant surface	Follow-up (in load) Years	Range	Mean	Treatment procedures Socket healing	Membr	Graft material	AB	Stage 1 or 2	Implant loss Before loading	During loading	Complications % bone loss ≥ ... mm	% att loss or PPD % ≥ ... mm	Esthetics general info/ % rec / ...	Peri-impl (% impl)
Becker et al 1999[50]	104/82	Nobel Biocare M	up to 5	1–5 y	?	#			2 h pre & post							
	49/38					0 d	ePTFE	No		2	3	0	NR	ND	ND	ND
	55/44					healed: deh/fen	ePTFE	Some		2	7	4	NR	ND	ND	ND
Becker et al 1998[51]	134/81	Nobel Biocare M	up to 5	1–5 y	84 mo	0 d	No	No	Pre	2	2	7	NR	NR	ND	ND
Chaushu et al 2001[52]	28/26	Steri-Oss HA & Alpha Bio HA	up to 2	6–24 mo		#			1 h pre & post				ND	ND	ND	ND
	19/?				13 mo	0 d	No	Autog		1	i	3	ND	ND	ND	ND
	9/?				16 mo	Healed	No	No		1	i	0	ND	ND	ND	ND
Covani et al 2004[53]	163/95	Premium SB/AE	4			#			Post				Bone level: 4% apical 1st T	NR	ND	ND
	58/?					0 d, < G	No	No		2	1	1	3/58	NR	ND	ND
	105/?					0 d, > G	Res	Autog		2	1	2	4/105	NR	ND	ND
De Bruyn and Collaert 2002[54]	184/42	Nobel Biocare M	up to 4	6 mo–4 y	?											
	15/6					0 d	No	No		1	6		NR	NR	ND	ND
	16/6					Healed	No	No		1	6		NR	NR	ND	ND
	153/30					No extr	No	No		1	1		NR	NR	ND	ND
Fugazzotto 2002[33]	63/57	–	up to 2 y	0–2 y		0 d, PMMx	No	Autog	ND	1	0	0	ND	ND	ND	ND
Gomez-Roman et al 2001[55]	124/104	Frialit-2 GB/AE	up to 6.3	3 mo–6.3 y	2.6 y	0–6 d	17: ePTFE	9: autog, 24: Algipore	13% cases	1	1	1	NR	NR	Optimal esthetics	*
Gotfredsen 2004[56]	20/20	Astra ST	5						ND				NR	ND	Crown length changes −1.5 to + 1.5 mm	0
	10/10					4 wk	ePTFE	No		2	0	0	NR	ND	cr. length > 0.3 mm; VAS dent 5.9 (2.9–9.5)	0
	10/10					12 wk	ePTFE	No		2	0	0	NR	ND	cr. length < 0.3 mm; VAS dent 8.4 (6.1–9.7)	0
Groisman et al 2003[57]	92/92	Nobel Biocare RT	up to 2	6 mo–2 y	?	0 d	No	Autog	Post	1	i	6	1% > 2 mm loss	ND	3 impl: > 2 mm rec, 4 impl lost papilla	ND
Kan et al 2003[58]	35/35	Nobel Biocare R, HA	> 1	12–48 mo	36 mo	0 d	No	No	Post	1	i	0	NR	ND	Fac rec: extr–1 y: 0.6 ± 0.5mm; Pr–1 y: 0.1 ± 0.2 mm; Papillae stable; Satisfaction 9.9	
Locante 2004[59]	86/86	Stabledent AO/GB	up to 3	12–42 mo	?	#			1 h pre & post				ND	ND	Predictable esthetic	ND
	46/46					0 d	No	FDB+Ca-P		1	1	0	ND	ND	ND	ND
	40/40					healed	No	No		1	0	0	ND	ND	ND	ND

Table 2 continued Implant Loss and Complications for Immediate and Early Placed Implants as Reported in Prospective Studies (in Alphabetic Order)

References	n impl / n pat	Implant surface	Follow-up (in load) Years	Range	Mean	Treatment procedures Socket healing	Membr	Graft material	AB	Stage 1 or 2	Implant loss Before loading	During loading	Complications % bone loss ≥ ... mm	% att loss or PPD % ≥ ... mm	Esthetics general info/ % rec / ...	Peri-impl (% impl)
Maló et al 2003[60]	116/76	Nobel Biocare M	1 y						1 h pre & ?				1 y: 14% > 2 mm	ND	2 cases unacceptable	
	22/14					0 d	no	no		1	i	0	ND	ND	ND	No infect
	94/62					healed	no	no		1	i	5	ND	ND	ND	No infect
Norton 2004[61]	28/28	Astra Tech ST	> 1	13–30 mo	20 mo				Pre & post				37.5% no bone loss	ND	1 impl unfavorable rec	ND
	16/16					0 d	no	no		1	i	0	ND	ND	ND	ND
	12 / 12					healed	no	no		1	i	1	ND	ND	ND	ND
Polizzi et al 2000[42]	264/143	Nobel Biocare M	up to 5	?	?	#			ND				5 y: > 2 mm: Mx 18%, Mn 12%	5 y: PD ≥ 4 mm Mx 27%, Mn 12%	ND	ND
Grunder et al 1999[41]	146/					0 d	No	No		2	5	4	ND	ND	ND	ND
	71/					0 d	64: res	17: DFDB		2	3	2	ND	ND	ND	ND
	34/					3–5 wk	No	No		2	2	1	ND	ND	ND	ND
	13/					3–5 wk	12: res	3: #		2	0	0	ND	ND	ND	ND
Prosper et al 2003[62]	111/83	Bioactive Covering TiSB	4			0 d			Post				ND	ND	ND	
	56/?						No	HA		2	1		ND	ND	ND	0
	55/?						Res	No		2	1	1	ND	ND	ND	0
Schropp et al 2005[63]	46/46	3I Osseotite	1.5						1 h pre & post				NR	ND better for 10 d impl	VAS scores	
Schropp et al 2003[64]	23/23					10 d	No	Autog at ab		2	2	0	NR	ND	Exposure metal margin in 2 p	1 infect
Schropp et al 2004[49]	23/23					3 mo	No	Autog		2	1	0	NR	ND	Exposure metal margin in 2 p	0
Yukna 1991[65] and 1992[66]	28/14	Calcitek I HA	up to 2	8–24 mo	16 mo				Post				NR	ND		indirect 0
	14/14					0 d	No	Calcitite		2	0	0	NR	ND	8 mo: rec 0.2 ± 0.2 mm	
	14/14					Healed	No	No		2	0	0	NR	ND	8 mo: rec 0.3 ± 0.2 mm	

Implant surface: AE = acid-etched, AO = aluminum oxide, GB = grit-blasted, HA = hydroxyapatite, I = Integral, M = machined, RT = Replace tapered, SB = sand-blasted, TPS = titanium plasma-sprayed. Treatment procedures: < G = small gap between the implant and bone, > G = large gap between the implant and bone, # = different types included in the study, autog = autograft, ab = abutment, CaP = calcium phosphate, deh/fen = dehiscences/fenestrations, DFDB = demineralized FDB, ePTFE = expanded polytetrafluoroethylene, FDB = freeze-dried bone, membr = membrane, PMMx = maxillary premolar, res = resorbable. Complications: extr = extraction, impl = implant, Mn = mandible, Mx = maxilla, ND = no data, NR = not reported, p = patient, PD = probing depth, PPD = periodontal probing depth, pr = provisionalization, rec = recession, T = thread, VAS = visual analog scale.

* 1% infection.

Table 3 Implant Loss and Complications for Immediate and Early Placed Implants as Reported in Retrospective Studies (in Alphabetic Order)

References	n impl / n pat	Implant surface	Follow-up (in load) Years	Range	Mean	Treatment procedures Socket healing	Membr	Graft material	AB	Stage 1 or 2	Implant loss Before Loading	During Loading	Complications % bone loss ≥ ... mm	% att loss or PPD % ≥ ... mm	Esthetics general info/ % rec / ...	Peri-impl (% impl)
Ashman et al 1995[67]	55/40	Steri-Oss M	8		8 y	0 d	No	HTR+in/ onlay	Post	2	1	0	ND	No deep pockets	Predictable esth/no score	ND
Bianchi et al 2004[68]	116/116	ITI ss	up to 9						ND							
	96/96			1–9 y		0 d	Connect tissue	No		2	0	0	DIB: 3–6y: 38% > 3.5 mm	3–6y: PD > 3 mm: 54%		ND
	20/20			6–9 y		0 d	No	No		1	0	0	DIB: 3–6y: 63% > 3,5 mm	3–6y: PD > 3 mm: 52%	Less stable	ND
Gelb 1993[69]	50/35	Nobel Biocare M	up to 3.6	8–44 mo	17 mo	#		DFDBA	Post				ND	ND	Universal patient satisfaction	ND
	13/?					0 d, 0 wall	12: ePTFE	13: DFDBA		2	0	0	ND	ND	ND	ND
	9/?					0 d, 3 wall	5: ePTFE	6: DFDBA		2	0	0	ND	ND	ND	ND
	28/?					0 d, circ	6: ePTFE	23: DFDBA		2	0	1	ND	ND	ND	ND
Goldstein et al 2002[70]	47/38	Nobel Biocare M, 3i	up to 5.5	1–5.5 y	39 mo	0 d	27: res	25: DFDBA	ND	2	0	0	ND	ND	ND	ND
Grunder 2001[71]	91/8	Osseotite, 3i	2 y			#			Post				DIB: 10 mo: 6.6% > 2 mm	ND	ND	ND
	66/					0 d	No	No		1	0	3	Mx 11/Ma 5% > 2 mm	ND	ND	ND
	25/					Healed	No	No		1	0	4	Mx 5/ Ma 0% > 2 mm	ND	ND	ND
Huys 2001[72]	556/147	ITI TPS hc/ hs/ss	up to 10	7–10 y		0 d	No	HTR	ND	1	19	0	ND	ND	ND	ND
Lang et al 1994[73]	21/16	ITI TPS hc	up to 3.5	21–42 mo	30 mo	0 d	ePTFE	No	Post	1	0	0	ND	ND	ND	ND
Maló et al 2000[74]	94/49	Nobel Biocare M	up to 2	6 mo–2 y					Pre & post				NR	ND	18 abut ex-changed for better esth	
	27/?					0 d	No	No		1	i	4	NR	ND	ND	No infect
	67/?					Healed	No	No		1	i	0	NR	ND	ND	No infect
Pecora et al 1996[35]	32/31	Minimatic TPS ss,hc	up to 2.8	3–34 mo	16 mo	0 d	10: ePTFE	No	Post	2	1	0	0% > 1.5 mm	ND	ND	No infect
Perry and Lenchewski 2004[75]	1099/442	Frialit-2 GB/AE	up to 5	6–67 mo	34 mo				ND		63	40	ND	ND	ND	ND
	322/?					0 d	No	No		2	32		ND	ND	ND	ND
	777/?					8–12 wk	No	No		2	71		ND	ND	ND	ND
Rosenquist and Grenthe 1996[40]	109/51	Nobel Biocare M	up to 5	1–67 mo	30 mo	0 d	5: ePTFE	No	post	2	6	1	ND	ND	ND	ND
Schwartz-Arad and Chaushu 1997[9]	95/49	Dentsply # types	up to 7	4–7 y	5 y	0 d	No	Some autog	Pre & post	2	5	0	ND	ND	ND	ND
Schwartz-Arad et al 2000[76]	56/43	# types	up to 5	4–60 mo	15 mo	0 d	6: res; 2: ePTFE	Some autog	Pre & post	2	5	1	ND	ND	ND	ND

Table 3 continued Implant Loss and Complications for Immediate and Eearly Placed Implants as Reported in Retrospective Studies (in Alphabetic Order)

References	n impl / n pat	Implant surface	Follow-up (in load)			Treatment procedures					Implant loss		Complications			
			Years	Range	Mean	Socket healing	Membr	Graft material	AB	Stage 1 or 2	Before Loading	During Loading	% bone loss ≥ ... mm	% att loss or PPD % ≥ ... mm	Esthetics general info/ % rec / ...	Peri-impl (% impl)
Watzek et al 1995[77]	134/20	IMZ / Nobel Biocare M	2 y post AB		27 mo				ND				NR	NR	ND	ND
	97/					0 d	# ePTFE	# BioOss/HA		2	1	0	NR	NR	ND	ND
	37/					≥ 6–8 wk	# ePTFE	# BioOss/HA		2	0	2	NR	NR	ND	ND
Wöhrle 2003[78]	14/14	Steri-Oss R#	up to 3	9 mo–3 y		0 d	Ño	Some Autog	ND	1	i	0	0% > 1 mm	ND	2 p > 1 mm recession	ND
Wolfinger et al 2003[79]	144/24	Nobel Biocare	up to 5	6 mo–5 y					ND				ND	ND	ND	ND
	82/					0 d	No	No		1 or 2		2	ND	ND	ND	ND
	62/					healed	No	No		1 or 2		3	ND	ND	ND	ND
Zitzmann et al 1999[80]	112/75	Nobel Biocare M	up to 2.3	6–28 mo	18 mo				local				ND	ND	ND	ND
	31 /					0 d	Res	Bio-Oss		2	1	0	ND	ND	ND	ND
	33 /					6 wk–6 mo	Res	Bio-Oss		2	1	1	ND	ND	ND	ND
	48 /					> 6 mo	Res	Bio-Oss		2	0	0	ND	ND	ND	ND

Implant surface: # = different surfaces, AE = acid-etched, GB = grit-blasted, hc = hollow cylinder, hs = hollow screw, M = machined, ss = solid-screw, TPS = titanium plasma-sprayed. Treatment procedures: # = different types included in the study, AB = antibiotics, autog = autograft, circ = circular, DFDBA = demineralized freeze-dried bone allograft, ePTFE = expanded polytetrafluoroethylene, HA = hydroxyapatite, HTR = calcium hydroxide, ND = no data, res = resorbable. Complications: DIB = distance from implant shoulder to first implant-bone contact, esth = esthetics, Mx = maxilla, Ma = mandible, ND = no data, NR = not reported, PD = probing depth, PPD = periodontal probing depth.

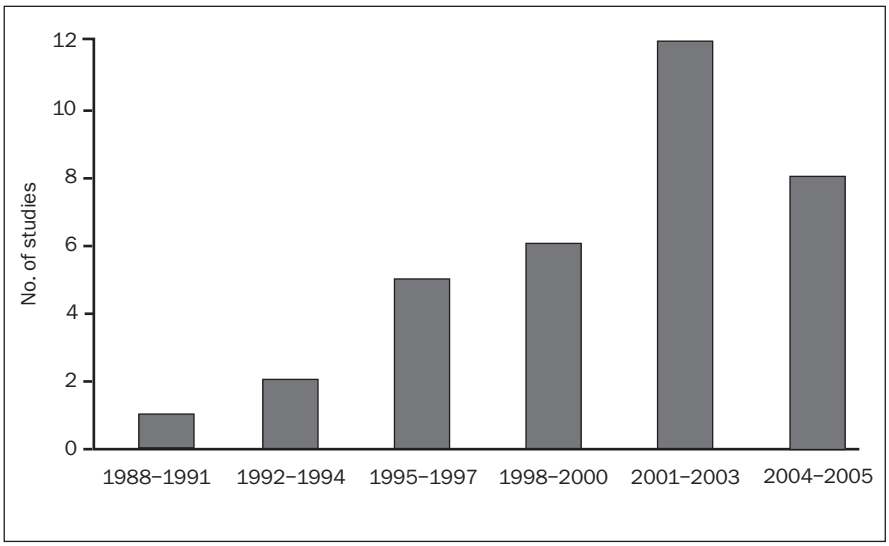


Fig 2 Papers by year of publication.

RESULTS

Paper Selection and Validity Assessment

The 351 initially retrieved abstracts were analyzed more in detail, and 205 were excluded because they were not relevant to this PICO question (Fig 1). Three independent reviewers (MQ, NVA, and DB) performed a full-text analysis of the 146 selected studies with possible relevance against the inclusion criteria. The interexaminer agreement for study in/exclusion was high (kappa score of > 0.86 with 95% agreement).

The data were stored in an Excel file (data abstraction form) to allow optimal comparison and to perform simple analysis (calculation of means and standard deviations). One hundred eight papers were excluded following full-text analysis. The main reasons for exclusion were lack of clinical data (n = 14), follow-up period too short (n = 10), number of patients and/or implants too small (n = 27), inability to breakdown the data for immediate versus delayed implant placement (n = 12), data restricted to healing explored via re-entry (n = 15), and information restricted to the technique only (n =12). A list of papers excluded from the review can be found in the Web edition of this paper. The 38 remaining papers were included without further quality assessment on aspects such as inclusion of general outcome confounders (eg, smoking, bone quality, or other confounders[82]), proper statistical analysis, presentation of inclusion/exclusion criteria, inclusion of objective outcome variables for implant success, inclusion of "all" consecutive patients, unbiased patient assignment, and blind data analysis. If several papers were published on the same study population, their data were grouped. The 38 selected papers, 21 prospective studies (17 clinical trials since some reported on same study) and 17 retrospective studies, are presented in Tables 2 and 3, respectively. Approximately half the papers reported on immediate or early placed implants only, whereas the others included a comparison with implants placed in so-called "healed sites." Most studies had been published after 2000 (20/34; Fig 2).

Figure 3 gives a simple classification on the quality appraisal of the included papers. In general this quality estimation was based on the study design. Less than a third of the studies reached an evaluation of better, and none of the studies was considered best quality. For more than two thirds of the studies the quality appraisal was below average.

Heterogeneity in Reports

Table 4 summarizes a series of parameters that showed extreme variations between different clinical reports. Socket (bony defect) characteristics for the immediately placed implants were an area of significant concern. In some studies, the implant was so wide or the defect diameter so small that there was only a minimal or even no gap between the implant surface and bony walls. In other trials the gap between the implant and alveolar crest was so large both horizontally and vertically that both a bone substitute and a membrane were used in the hope of achieving guided bone regeneration. The apicocoronal implant location in the osteotomy site is often scarcely mentioned. In several papers the implant shoulder is placed at the level of the mesial and distal bony crest, but in other papers the implants are placed much deeper. Some

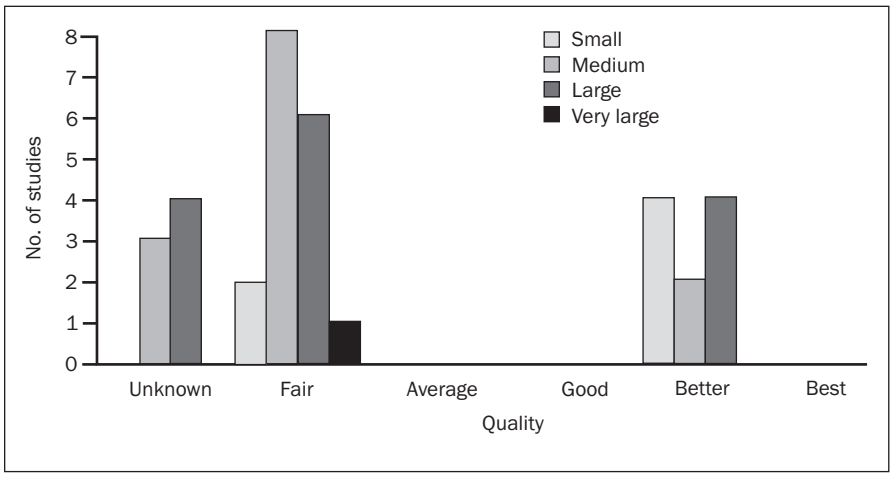


Fig 3 Papers by size and quality of the study.

papers even advocated removing the entire alveolar housing after tooth extraction (drastic alveoloplasty) before implant placement in order to engage only the basal bone.[83–85]

The applied inclusion/exclusion criteria also showed great interstudy variation. In some of the included studies all consecutive patients were enrolled; others used strict defect characteristics and even excluded patients with negative outcome confounders. Some papers restricted the indication to a certain area (eg, only mandibles, only maxillary first premolars), whereas others reported data for all oral regions. Some papers systematically excluded smokers, bruxers, or patients with poor oral hygiene or sites with an endodontic pathology, whereas others included them. The prosthetic rehabilitation also ranged from solitary implant cases to full fixed restorations. Finally, a series of implant surfaces and diameters had been used. Several papers did not include information on the aforementioned essential parameters.

The heterogeneity among the studies made a meta analysis impossible, or at least of questionable value. It would be useful if future publications contained clear information on the parameters presented in Table 4.

Clinical Outcomes

The number of patients included in the clinical trials ranged from 14 to 143 for the prospective studies (Table 2) and from 14 to 442 for the retrospective studies (Table 3). The corresponding number of implants ranged from 20 to 264, and from 14 to 1,099, respectively. A variety of implant geometries as well as surface characteristics were represented.

In general most papers only reported on implant loss (defined as removal from the oral cavity). Objective peri-implant tissue parameters such as attachment level changes, probing depth, suppuration, bleeding upon probing, or marginal bone level description were usually lacking. When clinical variables were scored, most often only mean values were reported (Tables 2 and 3).

Implant Survival. In total, in the prospective studies, 1,126 immediately placed and 90 implants placed according to an early or delayed protocol ("early placed" or "delayed placed" implants; healing time after extraction ranging from 3 to 12 weeks) in a group of 898 patients were reported on in the 17 selected studies.

The immediately placed implants showed a loss ranging from 0% to 40%, with an overall mean of 6.2% (SD 10.0%). For submerged immediately placed implants the loss was slightly lower (mean, 3.8%; SD 3.0%; range, 0.0% to 8.7%). For this subgroup, the loss was 2.6% before prosthetic loading and 1.3% afterward. In 8 of 17 papers with submerged healing, the implant loss was ≥ 5%. For immediately loaded immediately placed implants, a slightly larger proportion of losses 10.4%; range, 0.0% to 40%) was observed, especially for the minimally rough implants.

Seven studies compared immediately placed implants with implants placed in healed sites. From these studies no final conclusions can be drawn, since 2 papers reported more losses for implants in healed sites, while 2 others reported more losses for the immediately placed ones.

Three papers reported on early placed implants, with an overall mean loss rate of 3.6%, ranging from 0.0% to 6.4%.

The 17 selected retrospective studies (Table 3) reported all together on 1,776 immediately placed and 847 early or delayed placed implants (healing time after extraction ranging from 6 to 12 weeks),

Table 4 Parameters to be Included in Characterization of Conditions for Immediate/Early Implant Placement in Extraction Wounds

Parameter	Subparameter	Clarification	Suggestions for classification
Patient characteristics	History of periodontitis	Bone destruction due to periodontitis reduces the size/width of remaining sockets, affects fit of implant	Bony socket height measurement
Defect characteristics	Tooth type	Mandibular incisors or maxillary lateral incisors have smaller socket dimensions; maxillary second premolar has interradicular septum	Data analyses per subgroup, small versus wide sockets
	Extraction	A fenestration or dehiscence after tooth removal changes the protocol	Data on incidence of bony dehiscences
	Socket size	The wider and deeper the socket, the more difficult it is to obtain optimal fit of the implant and eventually the more difficult it becomes to reach a firm stabilization at the apex	Separate analyses for fitting or nonfitting implants
	Defect classification	Distinction between absence of the buccal plate, a 3-wall defect, or a circumferential defect is useful	A new classification (Fig 5)
	Bony walls	The approach might be different for 1-, 2-, or 3-wall defects	A new classification (Fig 5)
	Gap size	The dimension of the gap can show large variation and should be presented	A new classification (Fig 5)
	Tooth history	The incidence of bone pathology and eventual therapy must be mentioned	
	Location implant	Data about the relative position of the implant to the socket should be included	Description of whether the implant was in the middle of socket or toward the palatal plate and whether the shoulder of implant was above, at, or below the alveolar crest
Treatment strategy	Membrane	Use of resorbable or nonresorbable membrane might influence the chance for early exposure and of complication	
	Bone substitute	Use of bone substitutes may influence healing	
	Immediate loading	Subperiosteal healing may have different healing versus immediate transmucosal connection	
	Prosthetic design	Distinction between solitary and interconnected implants	

with 2 papers[72,75] being responsible for more than 1,600 implants.

The percentage of implant loss for immediately placed implants ranged from 0.0% to 14.8%, with an overall mean of 3.5% (SD 4.1%). However, 5 studies reported loss rates of at least 5%. The highest implant loss rates (7.3%) were again reported for immediately loaded immediately placed implants (eg, 14.8%[74], 7.2%[75]). For submerged immediately placed implants (mean loss, 2.4%; SD 3.2%), slightly lower rates were reported.

Four studies compared immediately placed implants with implants in healed sites. From these studies no final conclusions can be drawn, since 2 papers reported more loss for the implants in healed sites, while 2 reported more loss for the immediately placed ones. Only 3 papers included data on early/delayed placed implants, with an overall mean loss rate of 6.9%.

When all the papers were pooled (Fig 4), and only implant survival was considered (ie, loading time was ignored), late implants appeared to score slightly better than immediately placed implants, and both seemed to score better than the early placed implants. The heterogeneity between the studies, however, made valid and accurate comparison of the different insertion strategies impossible.

Crestal Bone Loss. Not a single study reported a frequency distribution on ranges of marginal bone loss for immediately placed implants. Thus, it was nearly

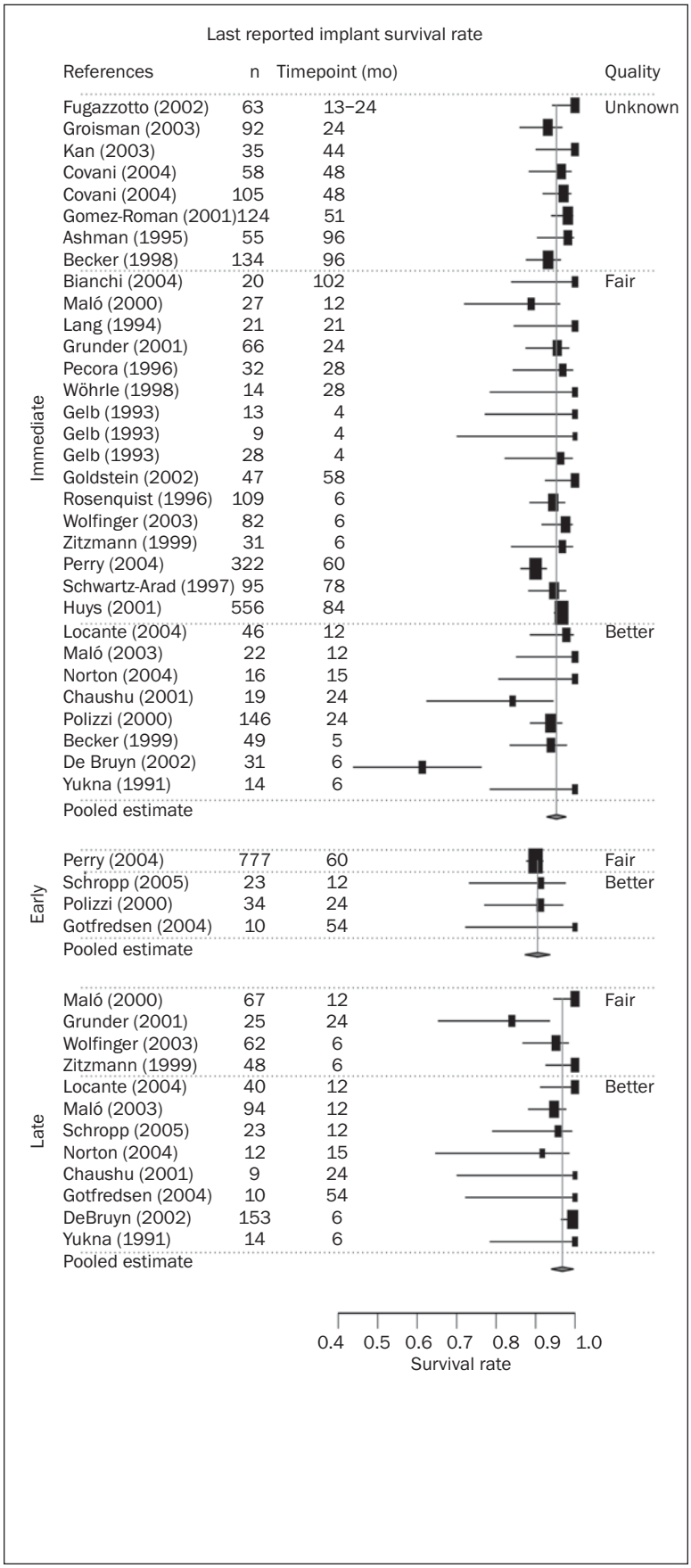


Fig 4 Last reported implant survival rate. Forest plots of implant survival data for immediate, early, and late placed implants. Only studies with clear life tables on implant level were included. For each study the following have been indicated: a rough classification of the respective study quality, the number of implants enrolled, last observation (expressed in months, often for only a small group of the initial implants; for detailed information see Tables 2 and 3), the mean survival rate (via the square box, with a size proportional to the number of enrolled implants), the 95% confidence interval of the survival rate (the endpoints of the horizontal line drawn through the square). For each subgroup an overall weighted mean (represented by the diamond; its width indicates the 95% confidence interval of pooled survival rate) has been calculated.

impossible to estimate the outcome of this variable. Such data were presented in 2 papers[42,60] for all implants included in the study (ie, they did not differentiate between immediately and delayed/late implants). These papers showed that after 1 and 5 years, 12% and 18% of the implants, respectively, lost more than 2 mm of marginal bone. Mean bone loss values were published in 11 of 17 prospective studies and 3 of 17 retrospective studies, but such data were considered not useful.

Soft Tissue Complications. Only a few prospective studies examined soft tissue changes. Frequency distributions of immediately placed implants with different degrees of attachment loss or probing depth were not found. Only 1 prospective study[42] and 1 retrospective study[68] reported frequency distributions of probing depths around immediately placed implants. After up to 6 years of loading, the proportion of immediately placed implants with pockets greater than 4 mm reached 20% in the Polizzi study,[42] whereas the proportion of implants with pockets greater than 3 mm reached 50% in the Bianchi study.[68]

Some authors indicated that some immediate implants exhibited serious gingival recession that resulted in an exposure of the metal margin of the implant.[49,56,57,60,61,86] Even though the incidence was small, it points to a possible concern when placing immediate implants in the esthetic zone.

Peri-implantitis. Unfortunately, most papers did not include this parameter. None of the papers included clear data on the incidence of peri-implantitis based on the Albrektsson criteria.[81] Some papers reported on peri-implant infections using the authors' own criteria. Such incidences were found to be very low.

DISCUSSION

A series of prospective and retrospective studies was included in this systematic review in order to analyze complications with immediate/early placed implants. Unfortunately, significant data were only available on implant loss. For immediately as well as early/delayed placed implants, an overall loss of around 5% was observed. Although these data correspond to results presented in a systematic review on implants in healed sites, when evaluating prospective studies with follow-up periods of more than 5 years,[2] it should be emphasized that the current review represents studies with considerably shorter follow-up periods. Some of the papers on immediately placed, immediately loaded implants reported higher failure rates, but in those cases implants with a minimally rough surface (Sa ± 0.5 μm)[87] had primarily been used. There is insufficient information on peri-implant health, prosthesis stability, degree of bone loss, and esthetic outcome of immediate as well as early/delayed placed implants.

A variety of classifications, with a lack of uniformity, was used for the timing between tooth extraction and implant placement.[11] Wilson and Weber[88] introduced the terms immediate, recent, delayed, and mature to describe the timing of implant placement in relation to soft tissue healing and the predictability of guided bone regeneration, but no guidelines for the time interval associated with these terms were provided. Mayfield[10] suggested the terms immediate, delayed, and late to describe healing periods of 0 weeks, 6 to 10 weeks, and 6 months or more after extraction, respectively, but unfortunately, the interval between 10 weeks and 6 months was not addressed. Most studies in this review used the term "immediate implant placement" when the implant was placed immediately following tooth extraction (ie, during the same surgery). Only Schropp and coworkers[23] used the term "immediate implantation" when implants were placed between 3 and 15 days following tooth extraction. The terms "early" or "delayed implant placement," however, were used for intervals ranging from 3 to 26 weeks. It seems more reasonable to use soft and hard tissue healing parameters instead. Hämmerle and coworkers,[89] for example, have suggested following classification:

1: Immediately—implant placement following tooth extraction as part of the same surgical procedure
2: Complete soft tissue coverage of the socket (typically 4 to 8 weeks after extraction)
3: Substantial clinical and/or radiographic bone fill of the socket (typically 12 to 16 weeks after extraction)
4: Complete fill of the socket (typically more than 16 weeks).

In this review, however, simply the time between tooth extraction and implant placement was used, without applying any further terminology.

Only in a few studies intraoral long-cone radiographs were systematically obtained for the longitudinal verification of marginal bone level changes. Of these papers, only 2 reported frequency tables, but no distinction was made between immediately placed implants and other implants. As such, it was impossible to estimate the number of implants exhibiting bone loss above a certain threshold level (eg, ≥ 2.5 mm). Mean values on bone loss were presented in several papers, but they are not very useful because they mask the outliers. For a clinician, it is

not the mean value but the outliers (eg, implants with severe bone loss or deep pockets and/or with peri-implantitis) that are of interest. The same is true for the probing depth values and the data on attachment level changes.

Frequencies of implants exhibiting symptoms of peri-implantitis were reported in only some studies; self-defined criteria were often applied. The majority of these studies used only probing assessments to identify peri-implantitis. Attachment level measurements, the presence of suppuration, and excessive bone loss were less frequently used. Interpretation of the data on the incidence of peri-implantitis is difficult because of the inconsistency in the assessment procedures.

Although esthetics was frequently cited as a reason for immediate implant placement, data on the esthetic outcome following immediate implant placement are still lacking. Although several papers reported on optimal esthetic outcomes, others warned of soft tissue complications, especially midfacial gingival recession with exposure of the abutment or implant neck.[49,56,58,60,61,74,86] Gotfredsen[56] and Schropp and coworkers[49] compared the esthetic outcome obtained between immediately and delayed placed implants. In the first study,[56] the best results were obtained with implants placed after 12 weeks of healing, compared to 4 weeks, whereas the second study[49] reported better esthetics with implant placement after 10 days instead of after 12 weeks. It is also important to notice that ratings of the esthetics made by patients are in general more positive than those of prosthodontists/periodontologists.[56,90]

Now that it has been established that the horizontal resorption of the alveolar ridge cannot be prevented by immediate implant placement, it may be more prudent to wait for at least soft tissue healing. A 2-month healing period may still be insufficient to evaluate complete bone remodeling at the buccal site of the healing extraction socket. Soft and/or hard tissue grafting, before, in combination with, or after immediate implant placement, can compensate for this ridge resorption and thus further improve the esthetic outcome.[11,14,91] A variety of techniques, including minimally invasive tooth extraction,[92] mobilization of flap,[93–96] soft tissue augmentation,[97,98] flapless procedures,[99] forced tooth eruption,[100] and scalloped implant design,[78] have been suggested but need further evaluation with respect to esthetic outcomes. The validity of each procedure would need to be determined by another systematic review.

An evaluation of the periodontal biotype[101-103] may be a useful guide for the prevention of soft tissue complications with immediate implant placement (for review see Sclar[14]). The thin, scalloped periodontium is characterized by a pronounced positive soft tissue architecture, friable soft tissues, minimal amounts of attached tissues, and a thin underlying alveolar bone with high frequencies of bony dehiscence and/or fenestration defects. Surgical procedures in such a periodontium typically result in some degree of soft tissue recession and underlying resorptive osseous remodeling. Such a thin periodontium has been associated with a triangular tooth form with small connector zones in the incisal third. This tooth morphology presents the additional esthetic challenge of preserving the existing soft tissues to minimize blunting of the papillae. In contrast, the thick, flat periodontium is characterized by relatively flat soft tissue and bony architecture; a dense, fibrotic soft tissue curtain with large amounts of attached tissues; and a thick osseous form that is resistant to resorption. This tissue is associated with a square tooth form with large connector zones. Such soft tissue is more resistant to gingival recession but slightly more susceptible to scarring at incision lines.

To reduce the heterogeneity between papers on immediate implant placement (Table 4), it is the recommendation of these authors that the inclusion of certain key parameters be considered mandatory. For many journals, this would require a revision of editorial policy. Special attention should be given to a clear description of the treated sites, so that the reader can clearly understand the clinical conditions.

Figure 5 summarizes the most essential variables for defect characterization; it includes defect classification (1- to 2-wall, 3-wall, or circumferential defect) as well as possible parameters. Looking from the occlusal plane (Fig 5a), 5 different conditions might be encountered. Group 0 represents the absence of a gap between implant and surrounding bone. Group I shows a circumferential defect, with Ia representing a gap ≤ 2 mm which renders the use of a grafting procedure unnecessary and Ib a condition where the gap is > 2 mm so that grafting might be recommended.[104–107] Group II presents 3-wall defects in either a buccolingual or mesiodistal direction, defects that normally have a good potential to heal spontaneously without augmentation.[23] Group III represents 2-wall defects (either at the buccal (b) or oral site (o)). Finally the 1- or no-wall defects are represented in group IV (implant outside the confines of the remaining bone). For groups III and IV, a further distinction should be made between a primarily suprabony defect or a defect with a significant infrabony part. In a vertical plane the implant might be positioned above, at, or below the marginal bone crest. For illustrations of essential defect parameters, see Fig 5b.

Fig 5a Classification of bony defect after immediate implant placement. Looking from the occlusal plane, 5 different conditions are highlighted: (0) absence of a gap between the implant and surrounding socket, (I) a circumferential defect with (a) a gap ≤ 2 mm or (b) a gap > 2 mm, (II) a 3-wall defect in either a mesiodistal (M/D) or buccolingual (B/L) direction, (III) a primarily 2-wall defect, (IV) a defect on 1 primary wall or a no-wall defect. In a vertical plane the implant might be positioned above (+), at (=), or below (−) the marginal bone crest. For III and IV, a further distinction should be made between a primarily suprabony defect (− infra) or a defect with a significant infrabony part (+ infra).

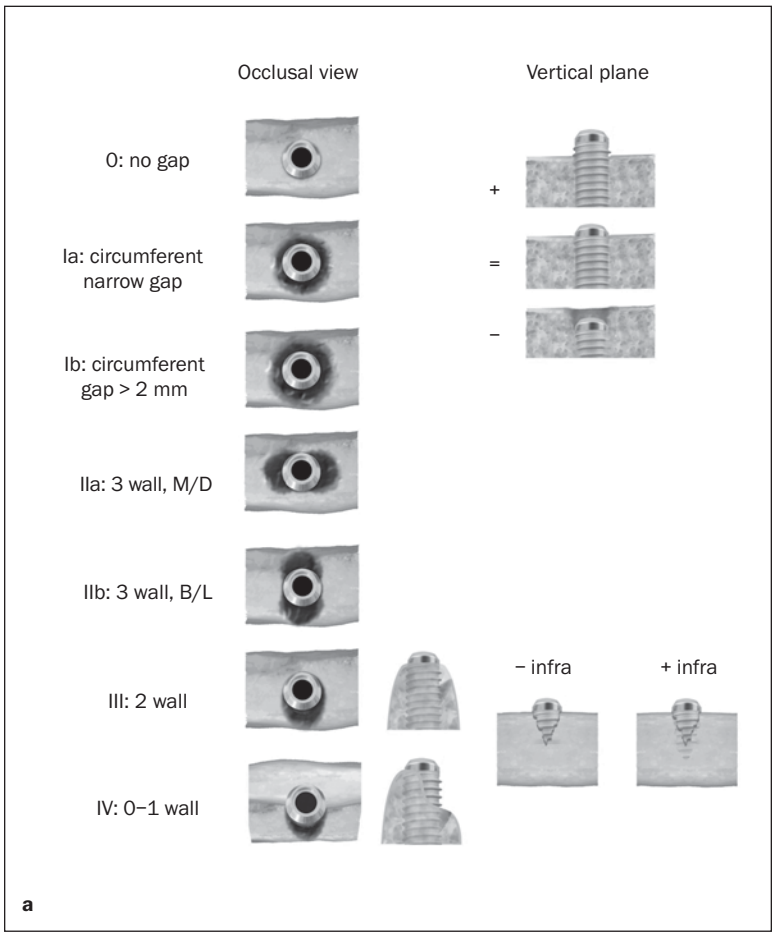
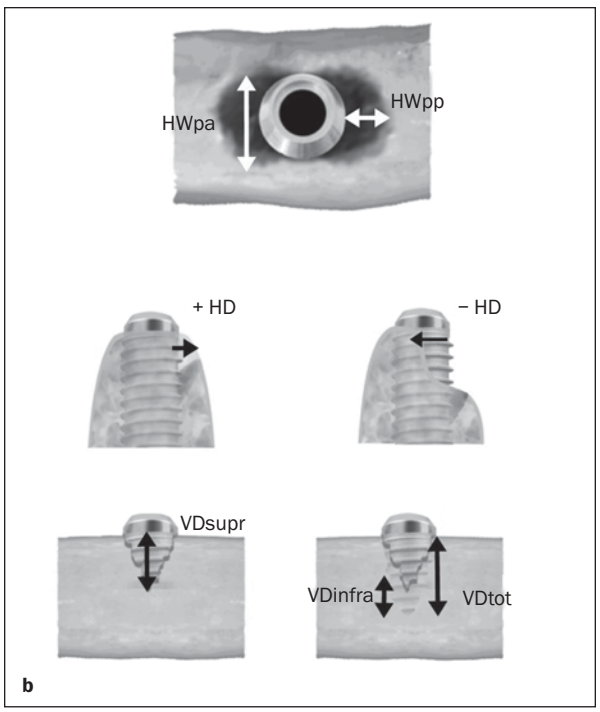


Fig 5b Useful parameters for characterizing the bony defect
HWpa: The horizontal width of the defect parallel to implant
HWpp: The horizontal width of the defect from the crest to the implant surface in a direction perpendicular to the long axis of the implant
VDsupr: Vertical depth of the defect measured along the implant long axis (implant-abutment junction to the bony crest)
VDinfra: vertical depth of the infrabony part
VDtot: total vertical depth; total vertical depth of the defect measured along the implant long-axis (implant-abutment junction to the bottom of the defect).
Figure based on Ashman et al,[67] Zitzmann et al,[80] and Schropp et al.[23]

CONCLUSIONS

1. The selected papers presented significant heterogeneity with respect to several aspects, including inclusion criteria, defect characteristics, treatment concept, and general validity of the paper. This heterogeneity rendered a generalized data analysis impossible.
2. Of the different complications, implant loss was most frequently described, while biologic complications (peri-implantitis, attachment loss, bone loss, gingival shrinkage/recession) were considered only sporadically.
3. The total incidence of implant loss after immediate implant placement was 4% to 5% (around 2.5% prior to prosthesis connection and 2% to 3% during function). The incidence of implant loss was higher when immediate implant placement was combined with immediate loading, especially for minimally rough implants.
4. Information on the incidence of peri-implantitis for immediate/early placed implants was lacking.



The data on soft tissue complications remains insufficient. Recent observations of resorption of the buccal bone plate in the first months after tooth extraction, irrespective of the presence of an implant, as well as some reports on gingival recessions resulting in exposed metal parts of the implant, should be considered when selecting patients for immediate/early implant placement.

REFERENCES

1. van Steenberghe D, Quirynen M, Naert I. Survival and success rates with oral endosseous implants. In: Lang N, Karring T, Lindhe J (eds). Proceedings of the 3rd European Workshop on Periodontology, Ittingen, Switzerland. Berlin: Quintessence, 1999:242–254.
2. Berglundh T, Persson L, Klinge B. A systematic review of the incidence of biological and technical complications in implant dentistry reported in prospective longitudinal studies of at least 5 years. J Clin Periodontol 2002;29(suppl 3):197–212.
3. Pjetursson BE, Tan K, Lang NP, Bragger U, Egger M, Zwahlen M. A systematic review of the survival and complication rates of fixed partial dentures (FPDs) after an observation period of at least 5 years. Clin Oral Implants Res 2004;15:625–642.
4. Esposito M, Grusovin MG, Coulthard P, Thomsen P, Worthington HV. A 5-year follow-up comparative analysis of the efficacy of various osseointegrated dental implant systems: A systematic review of randomized controlled clinical trials. Int J Oral Maxillofac Implants 2005;20:557–568.
5. Adell R, Lekholm U, Rockler B, Brånemark PI. A 15-year study of osseointegrated implants in the treatment of the edentulous jaw. Int J Oral Surg 1981;10:387–416.
6. Adell R, Eriksson B, Lekholm U, Brånemark PI, Jemt T. Long-term follow-up study of osseointegrated implants in the treatment of totally edentulous jaws. Int J Oral Maxillofac Implants 1990;5:347–359.
7. Albrektsson T. A multicenter report on osseointegrated oral implants. J Prosthet Dent 1988;60:75–84.
8. Schulte W, Kleineikenscheidt H, Lindner K, Schareyka R. The Tubingen immediate implant in clinical studies [in German]. Dtsch Zahnarztl Z 1978;33:348–359.
9. Schwartz-Arad D, Chaushu G. Placement of implants into fresh extraction sites: 4 to 7 years retrospective evaluation of 95 immediate implants. J Periodontol 1997;68:1110–1116.
10. Mayfield LJA. Immediate, delayed and late submerged and transmucosal implants. In: Proceedings of the 3rd European Workshop on Periodontology, Ittingen, Switzerland. Berlin: Quintessence, 1999:520–534.
11. Chen ST, Wilson TG Jr, Hammerle CH. 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.
12. Rosenquist B. A comparison of various methods of soft tissue management following the immediate placement of implants into extraction sockets. Int J Oral Maxillofac Implants 1997;12:43–51.
13. Douglass GL, Merin RL. The immediate dental implant. J Calif Dent Assoc 2002;30:362–374.
14. Sclar AG. Strategies for management of single-tooth extraction sites in aesthetic implant therapy. J Oral Maxillofac Surg 2004;62(suppl 2):90–105.
15. Palti A. Immediate placement and loading of implants in extraction sites: Procedures in the aesthetic zone. Dent Implantol Update 2004;15:41–47.
16. Becker W. Immediate implant placement: Diagnosis, treatment planning and treatment steps/or successful outcomes. J Calif Dent Assoc 2005;33:303–310.
17. Atwood DA. Some clinical factors related to the rate of resorption of residual ridges. J Prosthet Dent 1962;12:441–450.
18. Atwood DA. Postextraction changes in the adult mandible as illustrated by microradiographs of midsagittal sections and serial cephalometric roentgenographs. J Prosthet Dent 1963;13:810–825.
19. Johnson K. A study of the dimensional changes occurring in the maxilla after tooth extraction. Part I. Normal healing. Aust Dent J 1963;14:241–244.
20. Johnson K. A study of the dimensional changes occurring in the maxilla following tooth extraction. Aust Dent J 1969;14:241–244.
21. Carlsson GE, Persson G. Morphologic changes of the mandible after extraction and wearing of dentures. A longitudinal, clinical, and x-ray cephalometric study covering 5 years. Odontol Revy 1967;18:27–54.
22. Ulm C, Solar P, Blahout R, Matejka M, Gruber H. Reduction of the compact and cancellous bone substances of the edentulous mandible caused by resorption. Oral Surg Oral Med Oral Pathol 1992;74:131–136.
23. Schropp L, Wenzel A, Kostopoulos L, Karring T. Bone healing and soft tissue contour changes following single-tooth extraction: A clinical and radiographic 12-month prospective study. Int J Periodontics Restorative Dent 2003;23:313–323.
24. Camargo PM, Lekovic V, Weinlaender M, et al. Influence of bioactive glass on changes in alveolar process dimensions after exodontia. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2000;90:581–586.
25. Iasella JM, Greenwell H, Miller RL, et al. Ridge preservation with freeze-dried bone allograft and a collagen membrane compared to extraction alone for implant site development: A clinical and histologic study in humans. J Periodontol 2003;74:990–999.
26. Araujo MG, Sukekava F, Wennstrom JL, Lindhe J. Ridge alterations following implant placement in fresh extraction sockets: An experimental study in the dog. J Clin Periodontol 2005;32:645–652.
27. Araujo MG, Lindhe J. Dimensional ridge alterations following tooth extraction. An experimental study in the dog. J Clin Periodontol 2005;32:212–218.
28. Pietrokovski J, Massler M. Ridge remodeling after tooth extraction in rats. J Dent Res 1967;46:222–231.
29. Pietrokovski J, Massler M. Alveolar ridge resorption following tooth extraction. J Prosthet Dent 1967;17:21–27.
30. Botticelli D, Berglundh T, Lindhe J. Hard-tissue alterations following immediate implant placement in extraction sites. J Clin Periodontol 2004;31:820–828.
31. Covani U, Bortolaia C, Barone A, Sbordone L. Bucco-lingual crestal bone changes after immediate and delayed implant placement. J Periodontol 2004;75:1605–1612.
32. Botticelli D, Persson LG, Lindhe J, Berglundh T. Bone tissue formation adjacent to implants placed in fresh extraction sockets: An experimental study in dogs. Clin Oral Implants Res 2006;17:351–358.
33. Fugazzotto PA. Implant placement in maxillary first premolar fresh extraction sockets: Description of technique and report of preliminary results. J Periodontol 2002;73:669–674.
34. Novaes Junior AB, Novaes AB. Immediate implants placed into infected sites: A clinical report. Int J Oral Maxillofac Implants 1995;10:609–613.
35. Pecora G, Andreana S, Covani U, De Leonardis D, Schifferle RE. New directions in surgical endodontics; immediate implantation into an extraction site. J Endod 1996;22:135–139.

36. Novaes Junior AB, Vidigal Junior GM, Novaes AB, Grisi MF, Polloni S, Rosa A. Immediate implants placed into infected sites: A histomorphometric study in dogs. Int J Oral Maxillofac Implants 1998;13:422–427.
37. Novaes AB Jr, Marcaccini AM, Souza SL, Taba M Jr, Grisi MF. Immediate placement of implants into periodontally infected sites in dogs: A histomorphometric study of bone-implant contact. Int J Oral Maxillofac Implants 2003;18:391–398.
38. Quirynen M, Gijbels F, Jacobs R. An infected jawbone site compromising successful osseointegration. Periodontol 2000 2003;33:129–144.
39. Quirynen M, Vogels R, Alsaadi G, Naert I, Jacobs R, van Steenberghe D. Predisposing conditions for retrograde peri-implantitis, and treatment suggestions. Clin Oral Implants Res 2005;16:599–608.
40. Rosenquist B, Grenthe B. Immediate placement of implants into extraction sockets: Implant survival. Int J Oral Maxillofac Implants 1996;11:205–209.
41. Grunder U, Polizzi G, Goene R, et al. A 3-year prospective multicenter follow-up report on the immediate and delayed-immediate placement of implants. Int J Oral Maxillofac Implants 1999;14:210–216.
42. Polizzi G, Grunder U, Goene R, et al. Immediate and delayed implant placement into extraction sockets: A 5-year report. Clin Implant Dent Relat Res 2000;2:93–99.
43. Novaes AB Jr, Papalexiou V, Grisi MF, Souza SS, Taba M Jr, Kajiwara JK. Influence of implant microstructure on the osseointegration of immediate implants placed in periodontally infected sites. A histomorphometric study in dogs. Clin Oral Implants Res 2004;15:34–43.
44. Marcaccini AM, Novaes AB Jr, Souza SL, Taba M Jr, Grisi MF. Immediate placement of implants into periodontally infected sites in dogs. Part 2: A fluorescence microscopy study. Int J Oral Maxillofac Implants 2003;18:812–819.
45. Op Heij DG, Opdebeeck H, van Steenberghe D, Quirynen M. Age as compromising factor for implant insertion. Periodontol 2000 2003;33:172–184.
46. Op Heij DG, Opdebeeck H, van Steenberghe D, Kokich VG, Belser U, Quirynen M. Facial development, continuous tooth eruption and mesial drift as compromising factors for implant placement. Int J Oral Maxillofac Implants (in press).
47. Thilander B, Odman J, Lekholm U. Orthodontic aspects of the use of oral implants in adolescents: A 10-year follow-up study. Eur J Orthod 2001;23:715–731.
48. Bernard JP, Schatz JP, Christou P, Belser U, Kiliaridis S. Long-term vertical changes of the anterior maxillary teeth adjacent to single implants in young and mature adults. A retrospective study. J Clin Periodontol 2004;31:1024–1028.
49. Schropp L, Isidor F, Kostopoulos L, Wenzel A. Patient experience of, and satisfaction with, delayed-immediate vs. delayed single-tooth implant placement. Clin Oral Implants Res 2004;15:498–503.
50. Becker W, Dahlin C, Lekholm U, et al. Five-year evaluation of implants placed at extraction and with dehiscences and fenestration defects augmented with ePTFE membranes: Results from a prospective multicenter study. Clin Implant Dent Relat Res 1999;1:27–32.
51. Becker BE, Becker W, Ricci A, Geurs N. A prospective clinical trial of endosseous screw-shaped implants placed at the time of tooth extraction without augmentation. J Periodontol 1998;69:920–926.
52. Chaushu G, Chaushu S, Tzohar A, Dayan D. Immediate loading of single-tooth implants: Immediate versus non-immediate implantation. A clinical report. Int J Oral Maxillofac Implants 2001;16:267–272.
53. Covani U, Crespi R, Cornelini R, Barone A. Immediate implants supporting single crown restoration: A 4-year prospective study. J Periodontol 2004;75:982–988.
54. De Bruyn H, Collaert B. Early loading of machined-surface Brånemark implants in completely edentulous mandibles: Healed bone versus fresh extraction sites. Clin Implant Dent Relat Res 2002;4:136–142.
55. 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.
56. Gotfredsen K. A 5-year prospective study of single-tooth replacements supported by the Astra Tech implant: A pilot study. Clin Implant Dent Relat Res 2004;6:1–8.
57. Groisman M, Frossard WM, Ferreira HM, Menezes Filho LM, Touati B. Single-tooth implants in the maxillary incisor region with immediate provisionalization: 2-year prospective study. Pract Proced Aesthet Dent 2003;15:115–122, 124.
58. Kan JY, Rungcharassaeng K, Lozada J. Immediate placement and provisionalization of maxillary anterior single implants: 1-year prospective study. Int J Oral Maxillofac Implants 2003;18:31–39.
59. Locante WM. Single-tooth replacements in the esthetic zone with an immediate function implant: A preliminary report. J Oral Implantol 2004;30:369–375.
60. Maló P, Friberg B, Polizzi G, Gualini F, Vighagen T, Rangert B. Immediate and early function of Brånemark System implants placed in the esthetic zone: A 1-year prospective clinical multicenter study. Clin Implant Dent Relat Res 2003;5(suppl 1):37–46.
61. Norton MR. A short-term clinical evaluation of immediately restored maxillary TiOblast single-tooth implants. Int J Oral Maxillofac Implants 2004;19:274–281.
62. 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 a resorbable alloplastic material. Int J Oral Maxillofac Implants 2003;18:856–864.
63. Schropp L, Kostopoulos L, Wenzel A, Isidor F. Clinical and radiographic performance of delayed-immediate single-tooth implant placement associated with peri-implant bone defects. A 2-year prospective, controlled, randomized follow-up report. J Clin Periodontol 2005;32:480–487.
64. Schropp L, Kostopoulos L, Wenzel A. Bone healing following immediate versus delayed placement of titanium implants into extraction sockets: A prospective clinical study. Int J Oral Maxillofac Implants 2003;18:189–199.
65. Yukna RA. Clinical comparison of hydroxyapatite-coated titanium dental implants placed in fresh extraction sockets and healed sites. J Periodontol 1991;62:468–472.
66. Yukna RA. Placement of hydroxyapatite-coated implants into fresh or recent extraction sites. Dent Clin North Am 1992;36:97–115.
67. Ashman A, Lopinto J, Rosenlicht J. Ridge augmentation for immediate postextraction implants: Eight year retrospective study. Pract Periodontics Aesthet Dent 1995;7:85–94.
68. Bianchi AE, 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.
69. Gelb DA. Immediate implant surgery: Three-year retrospective evaluation of 50 consecutive cases. Int J Oral Maxillofac Implants 1993;8:388–399.
70. Goldstein M, Boyan BD, Schwartz Z. The palatal advanced flap: A pedicle flap for primary coverage of immediately placed implants. Clin Oral Implants Res 2002;13:644–650.

71. Grunder U. Immediate functional loading of immediate implants in edentulous arches: Two-year results. Int J Periodontics Restorative Dent 2001;21:545–551.
72. Huys LW. Replacement therapy and the immediate post-extraction dental implant. Implant Dent 2001;10:93–102.
73. Lang NP, Bragger U, Hammerle CH, Sutter F. Immediate transmucosal implants using the principle of guided tissue regeneration. I. Rationale, clinical procedures and 30-month results. Clin Oral Implants Res 1994;5:154–163.
74. Maló P, Rangert B, Dvarsater L. Immediate function of Brånemark implants in the esthetic zone: A retrospective clinical study with 6 months to 4 years of follow-up. Clin Implant Dent Relat Res 2000;2:138–146.
75. Perry J, Lenchewski E. Clinical performance and 5-year retrospective evaluation of Frialit-2 implants. Int J Oral Maxillofac Implants 2004;19:887–891.
76. 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.
77. 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.
78. Wöhrle PS. Nobel Perfect esthetic scalloped implant: Rationale for a new design. Clin Implant Dent Relat Res 2003;5(suppl 1):64–73.
79. Wolfinger GJ, Balshi TJ, Rangert B. Immediate functional loading of Brånemark system implants in edentulous mandibles: Clinical report of the results of developmental and simplified protocols. Int J Oral Maxillofac Implants 2003;18:250–257.
80. Zitzmann NU, Scharer P, Marinello CP. Factors influencing the success of GBR. Smoking, timing of implant placement, implant location, bone quality and provisional restoration. J Clin Periodontol 1999;26:673–682.
81. Albrektsson T, Isidor F. Consensus report: Implant therapy. In: Proceedings of the 1st European Workshop on Periodontology, Ittingen, Switzerland. Berlin: Quintessence, 1994:365–369.
82. 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.
83. Parel SM, Triplett RG. Immediate fixture placement: A treatment planning alternative. Int J Oral Maxillofac Implants 1990;5:337–345.
84. Krump JL, Barnett BG. The immediate implant: A treatment alternative. Int J Oral Maxillofac Implants 1991;6:19–23.
85. Tolman DE, Keller EE. Endosseous implant placement immediately following dental extraction and alveoloplasty: Preliminary report with 6-year follow-up. Int J Oral Maxillofac Implants 1991;6:24–28.
86. Wöhrle PS. Single-tooth replacement in the aesthetic zone with immediate provisionalization: Fourteen consecutive case reports. Pract Periodontics Aesthet Dent 1998;10:1107–1114.
87. Albrektsson T, Wennerberg A. Oral implant surfaces: Part 1—Review focusing on topographic and chemical properties of different surfaces and in vivo responses to them. Int J Prosthodont 2004;17:536–543.
88. Wilson TG, Weber HP. Classification of and therapy for areas of deficient bony housing prior to dental implant placement. Int J Periodontics Restorative Dent 1993;13:451–459.
89. 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.
90. Chang M, Odman PA, Wennstrom JL, Andersson B. Esthetic outcome of implant-supported single-tooth replacements assessed by the patient and by prosthodontists. Int J Prosthodont 1999;12:335–341.
91. Belser UC, Schmid B, Higginbottom F, Buser D. Outcome analysis of implant restorations located in the anterior maxilla: A review of the recent literature. Int J Oral Maxillofac Implants 2004;19(suppl):30–42.
92. Zeren KJ. Minimally invasive extraction and immediate implant placement: The preservation of esthetics. Int J Periodontics Restorative Dent 2006;26:171–181.
93. Nemcovsky CE, Artzi Z. Split palatal flap. I. A surgical approach for primary soft tissue healing in ridge augmentation procedures: Technique and clinical results. Int J Periodontics Restorative Dent 1999;19:175–181.
94. Nemcovsky CE, Artzi Z, Moses O. Rotated palatal flap in immediate implant procedures. Clinical evaluation of 26 consecutive cases. Clin Oral Implants Res 2000;11:83–90.
95. Nemcovsky CE, Artzi Z, Moses O, Gelernter I. Healing of dehiscence defects at delayed-immediate implant sites primarily closed by a rotated palatal flap following extraction. Int J Oral Maxillofac Implants 2000;15:550–558.
96. Nemcovsky CE, Moses O, Artzi Z, Gelernter I. Clinical coverage of dehiscence defects in immediate implant procedures: Three surgical modalities to achieve primary soft tissue closure. Int J Oral Maxillofac Implants 2000;15:843–852.
97. Chen ST, Dahlin C. Connective tissue grafting for primary closure of extraction sockets treated with an osteopromotive membrane technique: Surgical technique and clinical results. Int J Periodontics Restorative Dent 1996;16:348–355.
98. Landsberg CJ. Socket seal surgery combined with immediate implant placement: A novel approach for single-tooth replacement. Int J Periodontics Restorative Dent 1997;17:140–149.
99. 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.
100. Lin CD, Chang SS, Liou CS, Dong DR, Fu E. Management of interdental papillae loss with forced eruption, immediate implantation, and root-form pontic. J Periodontol 2006;77:135–141.
101. Ochsenbein C. Newer concept of mucogingival surgery. J Periodontol 1960;31:175–185.
102. Olsson M, Lindhe J. Periodontal characteristics in individuals with varying form of the upper central incisors. J Clin Periodontol 1991;18:78–82.
103. Olsson M, Lindhe J, Marinello CP. On the relationship between crown form and clinical features of the gingiva in adolescents. J Clin Periodontol 1993;20:570–577.
104. Wilson TG Jr, Schenk R, Buser D, Cochran D. Implants placed in immediate extraction sites: A report of histologic and histometric analyses of human biopsies. Int J Oral Maxillofac Implants 1998;13:333–341.
105. Paolantonio M, Dolci M, Scarano A, et al. Immediate implantation in fresh extraction sockets. A controlled clinical and histological study in man. J Periodontol 2001;72:1560–1571.
106. Wilson TG Jr, Carnio J, Schenk R, Cochran D. Immediate implants covered with connective tissue membranes: Human biopsies. J Periodontol 2003;74:402–409.
107. Chen ST, Darby IB, Adams GG, Reynolds EC. A prospective clinical study of bone augmentation techniques at immediate implants. Clin Oral Implants Res 2005;16:176–184.

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SECTION 8
CONSENSUS REPORT

How does the timing of implant placement after extraction affect outcomes?

Members of Section 8 evaluated the systematic review on the timing of implant placement after extractions. The focused PICO question addressed by the authors, Marc Quirynen and coworkers, of the evidence-based systematic review is: How does the timing of implant placement after extraction affect outcomes?

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

The section felt that the systematic review was complete and accurate.

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

The section felt that the following studies have appeared in the literature but do not change the conclusions of the systematic review:

One study (Wagenberg B, Froum S. A retrospective study of 1,925 consecutively placed immediate implants from 1988 to 2004. Int J Oral Maxillofac Implants 2006;21:71–81) evaluated 1,925 patients over a 5-year period. Among the conclusions were that if implant stability could be attained and residual infection removed, immediate implant placement is a highly successful procedure. In the 323 patients who smoked greater than half a pack of cigarettes per day, the failure rate was twice as high (4.6% versus 2.3%) compared to those who did not smoke. However, this was not statistically significant. Patients who were penicillin sensitive had a statistically higher failure rate. Implants with a moderately roughened surface (Sa value 1 to 2 μm) had higher survival rates than those with a minimally roughened surface (Sa value 0.5 μm). This result was statistically significant.

Jaffin and coworkers (Jaffin RA, Kolesar M, Kumar A, Ishikowa S, Fiorellini JP. The radiographic bone loss pattern adjacent to immediately placed, immediately loaded implants. Int J Oral Maxillofac Implants 2007 [in press]) treated 17 patients with hopeless maxillary and/or mandibular dentitions who had their remaining teeth extracted and 6 to 8 implants placed and restored within 72 hours. Radiographs were taken at time 0, 3 to 6 months, and annually for 5 years. The radiographs were digitized and the bone level changes were measured using a computer-assisted method. Over 54 months, implants placed into extraction sites lost 1.30 ± 0.48 mm of bone. Implants placed in native bone lost 1.45 ± 0.49 mm of bone over the same period.

Another prospective study (Oxby G, Lindqvist J, Nilsson P. Early loading of Astra Tech Osseospeed implants placed in thin alveolar ridges and fresh extraction sockets. Applied Osseointegration Res 2006;5:68–71) compared 29 immediate implants with 36 implants placed in healed bone. Periapical radiographs were taken at baseline, 6 months, and 12 months. No radiographic differences were observed between the 2 treatment groups regarding the height of the interproximal crestal bone.

In a study by Cornelini et al (Cornelini R, Cangini F, Covani U, Wilson TG Jr. Immediate restoration of implants placed into fresh extraction sockets for single-tooth replacement: A prospective clinical study. Int J Periodontics Restorative Dent 2005;25:439–447), 22 single-tooth implants placed and restored immediately had 100% 12-month survival and a mean radiographic bone resorption of 0.5 mm.

Davarpanah et al (Davarpanah M, Caraman M, Szmukler-Moncler S, Jakubowicz-Kohen B, Alcolforado G. Preliminary data of a prospective clinical study on the Osseotite NT implant: 18-month follow-up. Int J Oral Maxillofac Implants 2005;20:448–454) compared the survival of 182 implants in immediate, early, and delayed sites at 18 months. Implant survival was 97.79% in immediate and early sites compared to 98.75% in the delayed sites.

In a study to investigate the effect of hard tissue grafting on preservation of the facial plate of bone following tooth extraction (Nevins M, Camelo M, De Paoli S, et al. A study of the fate of the buccal wall of extraction sockets of teeth with prominent roots. Int J Periodontics Restorative Dent 2006;26:19–29), 9 patients were selected for extraction of 36 maxillary anterior teeth. All extractions were performed by "experienced" clinicians. Nineteen sites were grafted with a xenograft (test) while 17 sites received no graft (control). All sites were treated with primary flap closure. Computerized tomograms were performed immediately following extraction and repeated between 30 and 90 days to determine the fate of the buccal plate. They were evaluated by an independent radiologist. Sockets treated with the xenograft demonstrated a loss of less than 20% of

the buccal plate in 15 of 19 sites (79%). In contrast, 12 of the 17 control sockets (71%) experienced a loss of more than 20% of the buccal plate.

Chen and Darby (Chen S and Darby I. A prospective controlled clinical study of non-submerged immediate implants: Clinical outcomes and esthetic. Clin Oral Implants Res 2006 [accepted for publication]) compared gingival recession on the facial aspect of immediate implants that received xenografts, xenograft plus resorbable collagen membranes, or no grafting. They found that gingival recession was related to the facial-lingual implant position.

Two studies addressed the placement of immediate implants into infected sites. The first (Lindeboom JA, Tjiook Y, Kroon FH. Immediate placement of implants in periapical infected sites: A prospective randomized study in 50 patients. Oral Surg Oral Med Oral Pathol Radiol Endod 2006;101:705–710) reported a higher failure rate for immediately placed implants in sites with a history of periapical infections (2/25 implants lost versus 0/25 for noninfected sites). In the second (Villa R, Rangert B. Early loading of interforaminal implants immediately installed after extraction of teeth presenting endodontic and periodontal lesions. Clin Impl Dent Rel Res 2005;7(suppl 1):528–535), 20 patients were treated with 93 implants in the mandibular interforaminal area immediately after extractions. Some implants were placed "near" extraction sites while others were placed directly in extraction sites. All patients presented preoperatively with evidence of periodontal or periapical pathology in the area of implant placement. Survival rates were 100% at the time of provisional restoration and during the follow-up period (15 to 44 months), with a mean bone loss of 0.7 mm (SD 1.2 mm).

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

The section agrees with the conclusions. The group felt that the incidence of soft tissue complications (conclusion No. 5) can be influenced by the position of the implant (buccal to lingual), periodontal biotype, amount and type of graft material placed, and soft tissue augmentations.

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

Interpretation: To obtain meaningful data that can impact patient management, future studies should be performed. To assess outcomes in a standardized fashion that will allow cross-study comparisons, these studies should include the following criteria: a clear characterization of soft and hard tissue defects found in extraction sites, gingival recession, bone level measurements, and incidence of peri-implantitis.

Suggested areas of research include:

- Impact of the type of treatment on outcomes for the different types of osseous defects
- The effect of buccal plate thickness on esthetics
- The effect of the tissue biotype on esthetics
- The effect of the implant position on recession
- Clinical application and limitations of "flapless" surgery
- The effect of previous dental history on outcomes
- Whether there is an advantage to early placement
- The effect of site preservation on outcomes
- The effect of implant design and surface characteristics on outcomes

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

Due to the heterogeneity of studies published to date, it was not possible to compare the outcomes of immediately placed implants with implants placed in healed sites. Most papers reported high survival rates for immediate implant placement. Immediate implant placement offers shorter treatment time and fewer surgical procedures. However, there is some concern about the potential for soft/hard tissue complications after immediate implant placement. Clinicians must consider and understand the potential beneficial or adverse impact that the following factors may have on the functional and esthetic outcomes of immediate implant placement. These factors may include, but are not necessarily limited to:

Patient assessment

- General health of the patient
- History leading to tooth failure
- Esthetic evaluation
- Periodontal biotype
- Osseous morphology
- Health of the adjacent periodontium
- Site location of the implant
- Patient expectations
- Oral health status

Surgical technique

- Operator experience
- Minimizing trauma during extraction
- Removal of residual infection
- Appropriate use of antibiotics
- Choice of implant size, design, and surface characteristics
- Ability to achieve primary stability
- Position of the implant
- Requirements of grafting (hard and soft)

LIST OF PAPERS EXCLUDED AFTER FULL-TEXT SCREENING NOT MENTIONED IN REFERENCES

1. Aires I, Berger J. Immediate placement in extraction sites followed by immediate loading: A pilot study and case presentation. Implant Dent 2002;11:87–94.
2. 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.
3. 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.
4. Ashman A. An immediate tooth root replacement: An implant cylinder and synthetic bone combination. J Oral Implantol 1990;16:28–38.
5. Augthun M, Yildirim M, Spiekermann H, Biesterfeld S. Healing of bone defects in combination with immediate implants using the membrane technique. Int J Oral Maxillofac Implants 1995;10:421–428.
6. Babbush CA. The use of a new allograft material for osseous reconstruction associated with dental implants. Implant Dent 1998;7:205–212.
7. Barboza EP. Localized ridge maintenance using bone membrane. Implant Dent 1999;8:167–172.
8. Becker W, Dahlin C, Becker BE, et al. The use of e-PTFE barrier membranes for bone promotion around titanium implants placed into extraction sockets: A prospective multicenter study. Int J Oral Maxillofac Implants 1994;9:31–40.
9. Becker W, Becker BE, Hujoel P. Retrospective case series analysis of the factors determining immediate implant placement. Compend Contin Educ Dent 2000;21:805–808, 810–811, 814.
10. Block MS, Kent JN. Placement of endosseous implants into tooth extraction sites. J Oral Maxillofac Surg 1991;49:1269–1276.
11. 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.
12. Botticelli D, Berglundh T, Lindhe J. Hard-tissue alterations following immediate implant placement in extraction sites. J Clin Periodontol 2004;31:820–828.
13. Bragger U, Hammerle CH, Lang NP. Immediate transmucosal implants using the principle of guided tissue regeneration (II). A cross-sectional study comparing the clinical outcome 1 year after immediate to standard implant placement. Clin Oral Implants Res 1996;7:268–276.
14. Calvo Guirado JL, Saez Yuguero MR, Carrión del Valle MJ, Pardo Zamora G. A maxillary ridge-splitting technique followed by immediate placement of implants: A case report. Implant Dent 2005;14:14–18.
15. Calvo Guirado JL, Saez YR, Ferrer PV, Moreno Pelluz A. Immediate anterior implant placement and early loading by provisional acrylic crowns: A prospective study after a one-year follow-up period. J Ir Dent Assoc 2002;48:43–49.
16. Castellon P, Block MS, Smith M, Finger IM. Immediate implant placement and provisionalization using implants with an internal connection. Pract Proced Aesthet Dent 2004;16:35–43.
17. Castellon P, Yukna RA. Immediate dental implant placement in sockets augmented with HTR synthetic bone. Implant Dent 2004;13:42–48.
18. 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.
19. Cochran DL, Douglas HB. Augmentation of osseous tissue around nonsubmerged endosseous dental implants. Int J Periodontics Restorative Dent 1993;13:506–519.
20. Cooper LF, Rahman A, Moriarty J, Chaffee N, Sacco D. Immediate mandibular rehabilitation with endosseous implants: Simultaneous extraction, implant placement, and loading. Int J Oral Maxillofac Implants 2002;17:517–525.
21. Cordioli G, Majzoub Z, Riachi F. Postloading behavior of regenerated tissues in GBR-treated implant sites. Int J Periodontics Restorative Dent 1999;19:44–55.
22. Cornelini R. Immediate transmucosal implant placement: A report of 2 cases. Int J Periodontics Restorative Dent 2000;20:199–206.
23. Cornelini R, Scarano A, Covani U, Petrone G, Piattelli A. Immediate one-stage postextraction implant: A human clinical and histologic case report. Int J Oral Maxillofac Implants 2000;15:432–437.
24. Cornelini R, Cangini F, Martuscelli G, Wennstrom J. Deproteinized bovine bone and biodegradable barrier membranes to support healing following immediate placement of transmucosal implants: A short-term controlled clinical trial. Int J Periodontics Restorative Dent 2004;24:555–563.
25. Cosci F, Cosci B. A 7-year retrospective study of 423 immediate implants. Compend Contin Educ Dent 1997;18:940–942, 944, 946.
26. Covani U, Cornelini R, Barone A. Bucco-lingual bone remodeling around implants placed into immediate extraction sockets: A case series. J Periodontol 2003;74:268–273.
27. Covani U, Bortolaia C, Barone A, Sbordone L. Bucco-lingual crestal bone changes after immediate and delayed implant placement. J Periodontol 2004;75:1605–1612.
28. Covani U, Barone A, Cornelini R, Crespi R. Soft tissue healing around implants placed immediately after tooth extraction without incision: A clinical report. Int J Oral Maxillofac Implants 2004;19:549–553.
29. Cranin AN, Heimke G, Gelbman J, Simons A, Klein M, Sirakian A. Clinical trials with a polycrystalline alumina dental implant. J Oral Implantol 1993;19:221–227.
30. Dahlin C, Lekholm U, Becker W, et al. Treatment of fenestration and dehiscence bone defects around oral implants using the guided tissue regeneration technique: A prospective multicenter study. Int J Oral Maxillofac Implants 1995;10:312–318.
31. de Wijs FL, Van Dongen RC, De Lange GL, De Putter C. Front tooth replacement with Tubingen (Frialit) implants. J Oral Rehabil 1994;21:11–26.
32. de Wijs FL, Cune MS, De Putter C. Delayed implants in the anterior maxilla with the IMZ-implant system. J Oral Rehabil 1995;22:319–326.

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33. de Wijs FL, De Putter C, Cune MS. Front tooth replacement with Tubingen (Frialit) implants: A radiographical evaluation. J Oral Rehabil 1996;23:97–100.
34. Edel A. The use of a connective tissue graft for closure over an immediate implant covered with occlusive membrane. Clin Oral Implants Res 1995;6:60–65.
35. el Charkawi H. Immediate implant in fresh extraction socket of resected mandibular first molar: A preliminary clinical report. Implant Dent 2001;10:272–279.
36. Evian CI, Cutler S. Autogenous gingival grafts as epithelial barriers for immediate implants: Case reports. J Periodontol 1994;65:201–210.
37. Evian CI, Emling R, Rosenberg ES, et al. Retrospective analysis of implant survival and the influence of periodontal disease and immediate placement on long-term results. Int J Oral Maxillofac Implants 2004;19:393–398.
38. Fugazzotto PA, Shanaman R, Manos T, Shectman R. Guided bone regeneration around titanium implants: Report of the treatment of 1,503 sites with clinical reentries. Int J Periodontics Restorative Dent 1997;17:292–299.
39. Fugazzotto PA. Immediate implant placement following a modified trephine/osteotome approach: Success rates of 116 implants to 4 years in function. Int J Oral Maxillofac Implants 2002;17:113–120.
40. Fugazzotto PA. Simplified technique for immediate implant insertion into extraction sockets: Report of technique and preliminary results. Implant Dent 2002;11:79–82.
41. Fugazzotto PA. Guided bone regeneration at immediate implant insertion and loading: A case report. Implant Dent 2004;13:223–227.
42. Gher ME, Quintero G, Assad D, Monaco E, Richardson AC. Bone grafting and guided bone regeneration for immediate dental implants in humans. J Periodontol 1994;65:881–891.
43. Gher ME, Quintero G, Sandifer JB, Tabacco M, Richardson AC. Combined dental implant and guided tissue regeneration therapy in humans. Int J Periodontics Restorative Dent 1994;14:332–347.
44. Glauser R, Sennerby L, Meredith N, et al. Resonance frequency analysis of implants subjected to immediate or early functional occlusal loading. Successful vs. failing implants. Clin Oral Implants Res 2004;15:428–434.
45. Glickman RS, Bae R, Karlis V. A model to evaluate bone substitutes for immediate implant placement. Implant Dent 2001;10:209–215.
46. Gomez-Roman G, Schulte W, d'Hoedt B, Axman-Krcmar D. The Frialit-2 implant system: Five-year clinical experience in single-tooth and immediately postextraction applications. Int J Oral Maxillofac Implants 1997;12:299–309.
47. Graves SL, Jansen CE, Siddiqui AA, Beaty KD. Wide diameter implants: Indications, considerations and preliminary results over a two-year period. Aust Prosthodont J 1994;8:31–37.
48. Hammerle CH, Bragger U, Schmid B, Lang NP. Successful bone formation at immediate transmucosal implants: A clinical report. Int J Oral Maxillofac Implants 1998;13:522–530.
49. Hammerle CH, Lang NP. Single stage surgery combining transmucosal implant placement with guided bone regeneration and bioresorbable materials. Clin Oral Implants Res 2001;12:9–18.
50. Hui E, Chow J, Li D, Liu J, Wat P, Law H. Immediate provisional for single-tooth implant replacement with Brånemark system: Preliminary report. Clin Implant Dent Relat Res 2001;3:79–86.
51. Ibbott CG, Oles RD. Immediate implant post-surgical complications. J Can Dent Assoc 1995;61:193–198.
52. Jo HY, Hobo PK, Hobo S. Freestanding and multiunit immediate loading of the expandable implant: An up-to-40-month prospective survival study. J Prosthet Dent 2001;85:148–155.
53. Juodzbalys G. Instrument for extraction socket measurement in immediate implant installation. Clin Oral Implants Res 2003;14:144–149.
54. Khoury F, Happe A. The palatal subepithelial connective tissue flap method for soft tissue management to cover maxillary defects: A clinical report. Int J Oral Maxillofac Implants 2000;15:415–418.
55. Knox R, Lee K, Meffert R. Placement of hydroxyapatite-coated endosseous implants in fresh extraction sites: A case report. Int J Periodontics Restorative Dent 1993;13:245–253.
56. Langstaff WN. Immediate replacement of nonrestorable roots. J Oral Implantol 2001;27:311–316.
57. Lazzara RJ. Immediate implant placement into extraction sites: Surgical and restorative advantages. Int J Periodontics Restorative Dent 1989;9:332–343.
58. Leary JC, Hirayama M. Extraction, immediate-load implants, impressions and final restorations in two patient visits. J Am Dent Assoc 2003;134:715–720.
59. Ledermann PD, Hassell TM, Hefti AF. Osseointegrated dental implants as alternative therapy to bridge construction or orthodontics in young patients: Seven years of clinical experience. Pediatr Dent 1993;15:327–333.
60. Levine SS, Prewett AB, Cook SD. The use of a new form of allograft bone in implantation or osseointegrated dental implants—A preliminary report. J Oral Implantol 1992;18:366–371.
61. Locante WM. The nonfunctional immediate provisional in immediate extraction sites: A technique to maximize esthetics. Implant Dent 2001;10:254–258.
62. Maksoud MA. Immediate implants in fresh posterior extraction sockets: Report of two cases. J Oral Implantol 2001;27:123–126.
63. Mensdorff-Pouilly N, Haas R, Mailath G, Watzek G. The immediate implant: A retrospective study comparing the different types of immediate implantation. Int J Oral Maxillofac Implants 1994;9:571–578.
64. Nemcovsky CE, Artzi Z, Moses O. Rotated split palatal flap for soft tissue primary coverage over extraction sites with immediate implant placement. Description of the surgical procedure and clinical results. J Periodontol 1999;70:926–934.
65. Nemcovsky CE, Artzi Z, Moses O, Gelernter I. Healing of marginal defects at implants placed in fresh extraction sockets or after 4–6 weeks of healing. A comparative study. Clin Oral Implants Res 2002;13:410–419.
66. Nemcovsky CE, Artzi Z. Comparative study of buccal dehiscence defects in immediate, delayed, and late maxillary implant placement with collagen membranes: Clinical healing between placement and second-stage surgery. J Periodontol 2002;73:754–761.
67. Nir-Hadar O, Palmer M, Soskolne WA. Delayed immediate implants: Alveolar bone changes during the healing period. Clin Oral Implants Res 1998;9:26–33.
68. Nordin T, Nilsson R, Frykholm A, Hallman M. A 3-arm study of early loading of rough-surfaced implants in the completely edentulous maxilla and in the edentulous posterior maxilla and mandible: Results after 1 year of loading. Int J Oral Maxillofac Implants 2004;19:880–886.
69. Novaes AB Jr, Novaes AB. IMZ implants placed into extraction sockets in association with membrane therapy (Gengiflex) and porous hydroxyapatite: A case report. Int J Oral Maxillofac Implants 1992;7:536–540.
70. Nyman S, Lang NP, Buser D, Bragger U. Bone regeneration adjacent to titanium dental implants using guided tissue regeneration: A report of two cases. Int J Oral Maxillofac Implants 1990;5:9–14.

71. Ohrnell LO, Hirsch JM, Ericsson I, Brånemark PI. Single-tooth rehabilitation using osseointegration. A modified surgical and prosthodontic approach. Quintessence Int 1988;19:871–876.
72. Peleg M, Chaushu G, Blinder D, Taicher S. Use of lyodura for bone augmentation of osseous defects around dental implants. J Periodontol 1999;70:853–860.
73. Petrungaro PS. Immediate implant placement and provisionalization in edentulous, extraction, and sinus grafted sites. Compend Contin Educ Dent 2003;24:95–100, 103–104.
74. Quayle AA, Cawood J, Howell RA, Eldridge DJ, Smith GA. The immediate or delayed replacement of teeth by permucosal intra-osseous implants: The Tubingen implant system. Part 1. Implant design, rationale for use and pre-operative assessment. Br Dent J 1989;166:365–370.
75. Quayle AA, Cawood JI, Smith GA, Eldridge DJ, Howell RA. The immediate or delayed replacement of teeth by permucosal intra-osseous implants: The Tubingen implant system. Part 2: Surgical and restorative techniques. Br Dent J 1989;166:403–410.
76. Rebaudi A, Silvestrini P, Trisi P. Use of a resorbable hydroxyapatite-collagen chondroitin sulfate material on immediate postextraction sites: A clinical and histologic study. Int J Periodontics Restorative Dent 2003;23:371–379.
77. Rosen PS, Reynolds MA. Guided bone regeneration for dehiscence and fenestration defects on implants using an absorbable polymer barrier. J Periodontol 2001;72:250–256.
78. Rosenberg ES, Cho SC, Elian N, Jalbout ZN, Froum S, Evian CI. A comparison of characteristics of implant failure and survival in periodontally compromised and periodontally healthy patients: A clinical report. Int J Oral Maxillofac Implants 2004;19:873–879.
79. Rosenquist B, Ahmed M. The immediate replacement of teeth by dental implants using homologous bone membranes to seal the sockets: Clinical and radiographic findings. Clin Oral Implants Res 2000;11:572–582.
80. Schultz AJ. Guided tissue regeneration (GTR) of nonsubmerged implants in immediate extraction sites. Pract Periodontics Aesthet Dent 1993;5:59–65.
81. Schwartz-Arad D, Chaushu G. Full-arch restoration of the jaw with fixed ceramometal prosthesis. Int J Oral Maxillofac Implants 1998;13:819–825.
82. Schwartz-Arad D, Chaushu G. Immediate implant placement: A procedure without incisions. J Periodontol 1998;69:743–750.
83. 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.
84. Schwartz-Arad D, Levin L. Post-traumatic use of dental implants to rehabilitate anterior maxillary teeth. Dent Traumatol 2004;20:344–347.
85. Schwartz-Arad D, Yaniv Y, Levin L, Kaffe I. A radiographic evaluation of cervical bone loss associated with immediate and delayed implants placed for fixed restorations in edentulous jaws. J Periodontol 2004;75:652–657.
86. Sevor JJ, Meffert R. Placement of implants into fresh extraction sites using a resorbable collagen membrane: Case reports. Pract Periodontics Aesthet Dent 1992;4:35–41.
87. Simsek B, Simsek S. Evaluation of success rates of immediate and delayed implants after tooth extraction. Chin Med J 2003;116:1216–1219.
88. Tsai ES, Crohin CC, Weber HP. A five-year evaluation of implants placed in extraction sockets. J West Soc Periodontol Periodontal Abstr 2000;48:37–47.
89. van Steenberghe D, Callens A, Geers L, Jacobs R. The clinical use of deproteinized bovine bone mineral on bone regeneration in conjunction with immediate implant installation. Clin Oral Implants Res 2000;11:210–216.
90. Vergara JA, Caffesse RG. Immediate replacement of single upper posterior teeth: A report of cases. Clin Implant Dent Relat Res 2003;5:130–136.
91. Wagenberg BD, Ginsburg TR. Immediate implant placement on removal of the natural tooth: Retrospective analysis of 1,081 implants. Compend Contin Educ Dent 2001;22:399–404, 406, 408.
92. Werbitt MJ, Goldberg PV. The immediate implant: Bone preservation and bone regeneration. Int J Periodontics Restorative Dent 1992;12:206–217.
93. Wilson TG Jr. Guided tissue regeneration around dental implants in immediate and recent extraction sites: Initial observations. Int J Periodontics Restorative Dent 1992;12:185–193.
94. Yukna RA, Sayed-Suleyman A, Finley JM, Hochstedler J, Mayer ET. Use of HTR synthetic bone grafts in conjunction with immediate dental implants. Compend Contin Educ Dent 2003;24:649–652, 654, 657.
95. Yukna RA, Castellon P, Saenz-Nasr AM, et al. Evaluation of hard tissue replacement composite graft material as a ridge preservation/augmentation material in conjunction with immediate hydroxyapatite-coated dental implants. J Periodontol 2003;74:679–686.
96. Zitzmann NU, Naef R, Scharer P. Resorbable versus nonresorbable membranes in combination with Bio-Oss for guided bone regeneration. Int J Oral Maxillofac Implants 1997;12:844–852.