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ORIGINAL ARTICLE

Clinical evaluation of implant survival based on size and site of placement: A retrospective study of immediate implants at single rooted teeth sites

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Abstract *Objectives:* This retrospective clinical study sought to evaluate the survival of immediate implants placed at maxillary and mandibular single-rooted tooth extraction sites and to determine the relationship among implant size, placement site, and implant survival.

Methods: Between January 2010 and June 2011, 85 patients (33 males, 52 females; mean age: 45 years) underwent immediate implant placement after extraction of single-rooted teeth. All implants were restored between 12 and 14 weeks after implant placement. The implant survival and its relationship with implant size and implantation site were evaluated by odds ratios (ORs).

Results: Implants were placed at the following sites: upper central incisor (UCI, $n = 35$), upper lateral incisor (ULI, $n = 27$), upper second premolar (U2ndP, $n = 36$), lower incisor (LI, $n = 53$), and lower premolar (LP, $n = 22$). Implants of the following sizes were used: 5×10 mm ($n = 24$), 5×8 mm ($n = 21$), 4.3×10 mm ($n = 77$), 4.3×8 mm ($n = 36$), 3.5×10 mm ($n = 12$), and 3.5×8 mm ($n = 3$). After a mean follow-up time of 47 months, the overall implant survival rate was 96%. Survival rate was highest at the LI site (98.1%) and lowest at the ULI site (92.6%). All of the 5-mm implants survived (100%), as did most of the 4.3×10 mm implants (96.1%). Implants of 4.3×8 mm and 3.5×10 mm were the least successful (91.7%). Mandibular implants had a better survival rate (97.3%) than maxillary implants (94.9%). There was no significant OR of increased survival for any particular implant size or site.

Conclusions: Immediate implant placement in fresh extraction sockets can give predictable clinical outcomes, regardless of the implant size and site of placement.

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1. Introduction

Although the concepts of osseointegration (Branemark et al., 1977) have changed radically since its inception, the physiology underlying the process remains essentially the same. Implant placement can been classified as immediate, early, or delayed, with implants placed in the extraction site at the time of

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extraction, 2–4 weeks after extraction, or 4–6 months after extraction, respectively (Hammerle et al., 2004). The Glossary of Implant Dentistry of the International College of Oral Implantologists (Jalbout and Tabourian, 2008) defines immediate implant placement as ''placement of a dental implant at the time of tooth extraction, into the extraction socket''.

Advantages of immediate implant placement include alveolar ridge preservation, reduction in marginal bone loss after extraction, and a short treatment time, all of which imply an overall benefit to the patient (Kahnberg, 2009; Penarrocha-Diago et al., 2011). Within 6 months after extraction, the alveolar bone undergoes width and height reductions of up to 3.8 mm and 1.24 mm, respectively (Chen et al., 2004; Hammerle et al., 2004). Immediate implants placed in fresh extraction sockets resulted in mesial and distal marginal bone reductions of only 0.13 mm and 0.19 mm, respectively. Thus, there seems to be a causative relationship between immediate implant placement and ridge preservation (Kahnberg, 2009).

Successful rehabilitation of the aesthetic zone is achievable with an aesthetic restoration supported by an implant (Misch et al., 2008). To obtain predictable aesthetic outcomes, stability of the peri-implant tissues needs to be maintained, which is possible by correct positioning of the immediately placed implant (Malchiodi et al., 2013; Tortamano et al., 2010). Several studies have reported the merits of immediate implant placement over early and delayed placement; however, the timing of implant loading remains controversial (Chen et al., 2004; Kahnberg, 2009; Malchiodi et al., 2013; Penarrocha-Diago et al., 2011; Schropp and Isidor, 2008; Tortamano et al., 2010). Based on a Cochrane review, Esposito et al. (2013) reported that different implant loading times did not result in clinically important differences with regard to prosthesis/implant failure or peri-implant bone loss.

Aims of the present study were as follows: (1) to evaluate the 3-year survival rate of osseointegration, on the basis of clinical examination, for immediate implants placed at different single-rooted dental extraction sites, and (2) to examine the relationship among implant size, placement site, and implant survival.

2. Methods

2.1. Patients

The sampling frame for this study consisted of patients who had been referred to the Oral and Maxillofacial Surgery Clinic at the College of Dentistry, King Saud University (Riyadh, Saudi Arabia) for immediate implant rehabilitation after extraction of single-rooted teeth. To ensure a minimum 3-year follow-up period after implant placement, the study sample was limited to patients who were treated between January 2010 and June 2011. Exclusion criteria included the presence of acute inflammation or acute exacerbation of a chronic inflammation in the offending tooth at the time of extraction, uncontrolled systemic illness, pregnancy, lactation, anticoagulant therapy, smoking habit, and poor oral hygiene practices. All patients provided written informed consent about the surgical procedure and implant placement before the procedure. Ethical approval for the study was obtained from the institutional ethics committee of the College of Dentistry Research Center of the King Saud University. The physical status of all enrolled patients could be classified as American Society of Anesthesiologists (ASA)1 or ASA2.

2.2. Surgical technique

Under aseptic conditions, local anaesthesia (2% lidocaine with 1:80,000 epinephrine, Dentsply Pharmaceuticals, USA) was administered, followed by atraumatic tooth extraction with particular emphasis on preserving the marginal alveolar bone. The extracted socket was irrigated with normal saline solution (0.9% NaCl) to clean the wound off debris and potential chronic inflammatory elements. Dental implants (Nobel Replace Select Tapered; Noble Biocare, Gutenberg, Sweden) were placed in the fresh extraction sockets, in a palatal position in the maxilla and in the corresponding lingual position in the mandible, by using a two-stage surgical protocol.

The implant site was prepared by using a rotary handpiece with coolant irrigation. Instrumentation specific for the implant (Nobel Replace Select Tapered Instrumentation; Nobel Biocare) was used. The implant size was determined on the basis of the diameter of the extraction socket and its anatomic location. Pilot drilling at the apex of the extraction socket was initially performed with a 2-mm twist drill, for a depth of up to 3 mm, which was confirmed by measuring the preparation with a depth gauge (KLS Martin, Germany). This step was followed by preparation with a 3-mm twist drill up to the previously determined preparation depth. Further preparation of the implant site was done in accordance with the manufacturer's recommended sequence, until the final drill diameter was reached and the desired diameter of the implant site for implant placement was achieved.

The implant fixture was placed with a minimum placement torque of at least 35 cm N to ensure stability. The implant was submerged 2 mm below the crestal bone (Fig. 1). Implants inserted at lower premolar extraction sites were placed at least 2 mm away from the mental foramen. Cover screws were placed in all implants. Where indicated, the residual gap between the implant and the socket wall was filled with autologous bone that had been harvested from the maxillary tuberosity. After implant placement, the mucogingival flaps were approximated and closed with absorbable sutures (4–0 Ethicon coated vicryl, Johnson and Johnson, USA).

Patients received postoperative oral antibiotic (500 mg of amoxicillin; GlaxoSmithKline, Middlesex, UK) every 8 h for 5 days. Patients who were allergic to beta-lactam antibiotics were prescribed 300 mg of clindamycin (Pfizer, NY, USA) every 6 h for 5 days. All patients were advised to take 500-mg Paracetamol tablets for pain relief, when needed. The same clinician (NN) performed all of the surgical procedures. All implants were restored between 12 and 14 weeks after their initial placement.

2.3. Follow-up evaluation

All patients were evaluated during the first week after surgery, during the second stage of the implant procedure, 3 months after prosthodontic crown placement, and 1 year after restoration. Patients were followed up for at least 3 years after implant placement. During each follow-up visit, the patients were examined clinically for implant stability and peri-implant inflammation. Radiographs of the implant site were taken before the

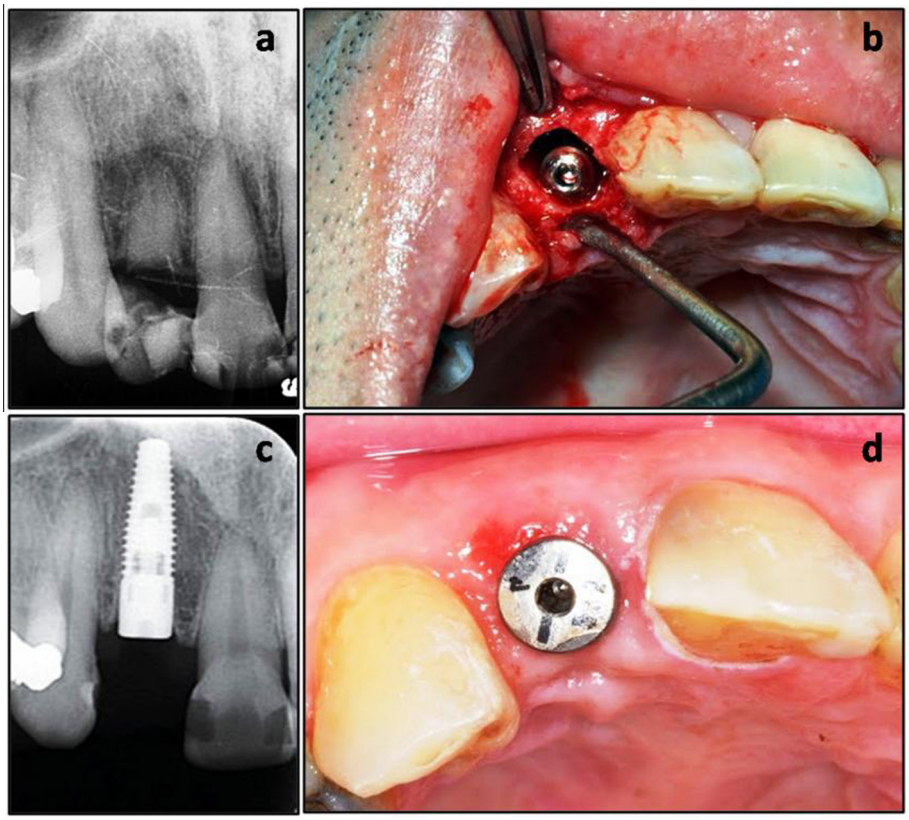

Figure 1 Immediate implant placement in the right upper lateral incisor (#12) site. (a) Pre-operative PA radiograph showing non restorable tooth #12. (b) Immediate implant placed in the extraction socket. (c) Post-operative PA radiograph to confirm osseointegration of the implant. (d) Peri-implant healing prior to second stage implant surgery.

second stage of the surgery and 1 year after restoration. Implant survival was assessed for each implant on the basis of functional outcomes, such as the implant stability, absence of pain or inflammation in peri-implant tissues, and unhindered masticatory function. The above clinical parameters were considered to be indicators of successful osseointegration (see Fig. 2).

2.4. Statistical analysis

Implant survival was calculated for all implants and was subclassified according to implant size and placement site. Dichotomous variables pertaining to implant survival and its relationship to the implant size and placement site were evaluated by odds ratios (ORs) and 95% confidence intervals (CIs). The significance level was set at 0.05 (p-value < 0.05).

3. Results

Between January 2010 and June 2011, a total of 135 patients underwent immediate implant placement at the implant clinic after extraction of single-rooted teeth. Among them, only 85 patients (33 males, 52 females; mean age: 45 years; age range: 27–48 years) fulfilled the inclusion criteria. A total of 173 implants were placed in these 85 patients immediately after extraction of single-rooted maxillary and mandibular teeth. The sites of extraction were as follows: upper central incisor (UCI, $n = 35$), upper lateral incisor (ULI, $n = 27$), upper 2nd premolar (U2ndP, $n = 36$), lower incisor (LI, $n = 53$), and lower premolar (LP, $n = 22$), as shown in Table 1. The overall implant survival rate was 96% after a mean follow-up period of 47 months (range: 38–52 months). Failure of osseointegration was observed in seven implants, which were removed before the second stage.

Implants placed at the ULI extraction site had the lowest survival rate (92.6%, 2/27 implants failed). The LI extraction site had the highest survival rate (98.1%). There were two implant failures among the implants placed at the UCI and ULI extraction sites, respectively. All other sites had only one failed implant per extraction site. Mandibular implants had a better survival rate (97.3%, 2/75 implants failed) than maxillary implants (94.9%, 5/98 implants failed), with an OR of 1.03 (95% CI: 0.67–1.58; $p = 0.9079$; Table 1).

As shown in Table 2, the large-diameter 5-mm implants ($n = 45$) had the highest survival rate (100%), followed by the 4.3×10 mm implants (96.1%, 3/77 implant failures). The 4.3×8 mm and 3.5×10 mm implants had similar survival rates (91.7%), with a total of four implants failing out of the 48 placed. Although the 3.5×8 mm implants exhibited a survival rate of 100%, the number of implants ($n = 3$) was too low for comparison with implants of other sizes. The 4.3-mm implants ($n = 113$) were used predominantly in this study, with an overall survival rate of 94.7% (Table 3).

The OR of increased survival was not significantly increased for any particular implant size (Table 4) or site (Table 5). Nevertheless, the OR values of implant survival were generally higher for 5×10 mm, 5×8 mm, and 4.3×10 mm implants. Similarly, implants placed at the mandibular incisor (LI) extraction sites had a better OR of survival compared to implants placed at all other sites.

4. Discussion

Implants placed immediately after extraction of single-rooted teeth in the maxilla and mandible had an overall survival rate

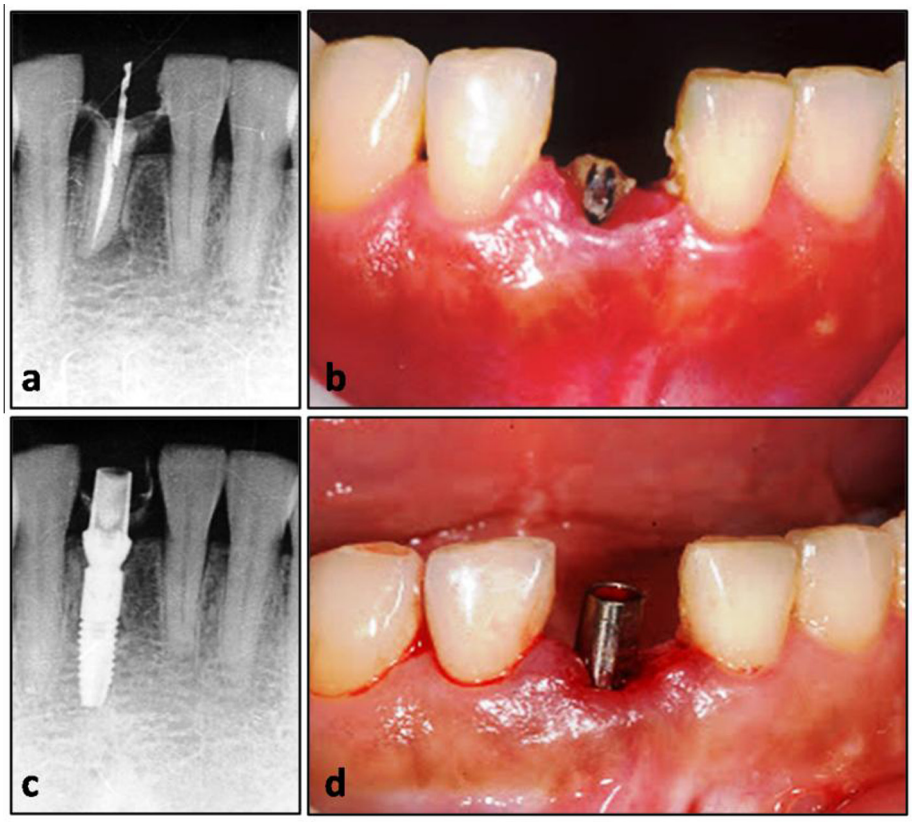

Figure 2 Immediate implant placement in the right lower central incisor (#41) site. (a) Pre-operative PA radiograph showing non restorable tooth #41. (b) Pre-operative clinical photograph of tooth #41 showing loss of complete crown. (c) Post-operative PA radiograph taken to confirm osseointegration of the implant. (d) Healing abutment placed at the time of second stage implant surgery.

Table 1 Implant survival rates based on site of implant placement.

Site of implant placement*	Implants placed (*n*)	Implants survived		Implants failed	
		n	%	*n*	%
UCI	35	33	94.3	2	5.7
ULI	27	25	92.6	2	7.4
U2ndP	36	35	97.2	1	2.8
LI	53	52	98.1	1	1.9
LP	22	21	95.5	1	4.5
Total	173	166	96	7	4

* UCI, upper central incisor; ULI, upper lateral incisor; U2ndP, upper 2nd premolar; LI, lower incisor; LP, lower premolar.

Table 2 Implant survival rates based on size of implant placed.

Size of implant placed (mm)	Implants placed (*n*)	Implants survived		Implants failed	
		n	%	*n*	%
5×10	24	24	100	0	0
5×8	21	21	100	0	0
4.3×10	77	74	96.1	3	3.9
4.3×8	36	33	91.7	3	8.3
3.5×10	12	11	91.7	1	8.3
3.5×8	3	3	100	0	0
Total	173	166	96	7	4

Table 3 Sizes of implants placed at different extraction sites and their survival rates.

Site of implant placement*	Sizes of implants placed (mm)															
	5 × 10			5 × 8			4.3 × 10			4.3 × 8			3.5 × 10			3.5 × 8		
	Implants (*n*)	Failure (*n*)	Survival rate (%)	Implants (*n*)	Failure (*n*)	Survival rate (%)	Implants (*n*)	Failure (*n*)	Survival rate (%)	Implants (*n*)	Failure (*n*)	Survival rate (%)	Implants (*n*)	Failure (*n*)	Survival rate (%)	Implants (*n*)	Failure (*n*)	Survival rate (%)
UCI	11	0	100	1	0	100	9	1	90	2	1	66.7	–	–	–	–	–	–
ULI	–	–	–	–	–	–	6	1	85.7	9	0	100	8	1	87.5	3	0	100
U2ndP	8	0	100	6	0	100	17	1	94.4	4	0	100	–	–	–	–	–	–
LI	–	–	–	–	–	–	34	0	100	14	1	93.3	4	0	100	–	–	–
LP	5	0	100	4	0	100	8	0	100	4	1	80	–	–	–	–	–	–

* UCI, upper central incisor; ULI, upper lateral incisor; U2ndP, upper 2nd premolar; LI, lower incisor; LP, lower premolar.

of 96%. There were seven implant failures out of the 173 implants placed.

Although several studies (Garcia et al., 2009; Lops et al., 2008; Mangano et al., 2012) have reported 100% survival rates after immediate implant placement in the maxilla and mandible with follow-up periods of up to 2 years, the total number of implants in the present study was considerably higher than that of previous studies. Results of the present study are comparable to the 97% implant survival rates reported by De Rouck et al. (2008) and Gomez-Roman et al. (2001). Of the seven failed implants in this study, the UCI and ULI sites had two failures each. All other sites (U2ndP, LI, and LP) had one failure each. All of the failures were detected before implant loading and could not be attributed to any one particular reason.

The significant positive influence of atraumatic extraction techniques on immediate implant osseointegration and survival is well documented (Blus and Szmukler-Moncler, 2010). In the present study, the surgeon was careful to perform all dental extractions atraumatically. A prospective multicentre study by Polizzi et al. (2000) reported survival rates for immediate implants as high as 92.4% in the maxilla and 94.7% in the mandible. They concluded that the severity of inflammation at the extracted site can significantly influence immediate implant survival negatively. This conclusion was supported by the results of a large clinical case series by Wagenberg and Froum (2006). Cases of acute inflammation or acute exacerbation of a chronic inflammation at the implant site were excluded from the present study. Although the mandibular implants had a better survival rate than maxillary implants, this difference was not significant.

In a retrospective analysis of 1649 maxillary and mandibular implants, Olate et al. (2010) found no significant relationship between implant diameter and early failure; however, they did report a significant negative influence of short implant length on implant survival. Large-diameter implants are considered to be the ideal choice for immediate implantation in extracted sockets, to compensate for the apically narrow and crestally flared root shape (Lee et al., 2005). Implants of various diameters (range: 3.5–5 mm) and implant lengths of 8 or 10 mm were placed in the present study. Although larger implants had a better overall survival compared to smaller implants, there was no particular implant size that had a significantly increased survival compared to the other implant sizes.

Several studies have reported placement of immediate implants in the maxillary anterior aesthetic zone, with survival rates ranging from 96% to 100% (De Rouck et al., 2008; Garcia et al., 2009; Kan et al., 2003; Mangano et al., 2012; Tortamano et al., 2010). The maxillary anterior aesthetic zone includes the incisor and canine teeth. In this study, no implants were placed in the maxillary canine region. Among the implants placed at maxillary incisor extraction sites, the UCI implants had a better survival rate (94.3%) than ULI implants. Fugazzotto (2002) reported placement of 63 immediate implants in the maxillary first premolar extraction site after removal of the residual interradicular bone, with no cases of osseointegration failure. Moreover, 41 implants were still functional after 2 years. In this study, no implants were placed in the maxillary first premolar site. However, implants placed at the second premolar extraction site demonstrated a survival rate of 97.2%, with only one failure out of 35 implants.

Studies by Schwartz-Arad et al. (2007) and Oyama et al. (2012) reported immediate implant placement in the mandible

Table 4 Odds ratios of survival based on implant size.

Implant size (mm)	5 × 10	5 × 8	4.3 × 10	4.3 × 8	3.5 × 10
5 × 10	**1**	**1.14** (0.02–59.93) *0.95*	**2.30** (0.11–46.15) *0.58*	**5.12** (0.25–103.72) *0.29*	**6.39** (0.24–169.25) *0.27*
5 × 8	**0.88** (0.02–46.15) *0.95*	**1**	**2.02** (0.10–40.65) *0.65*	**4.49** (0.22–91.35)*0.33*	**5.61** (0.21–149.02) *0.30*
4.3 × 10	**0.43** (0.02–8.71) *0.59*	**0.49** (0.02–9.96) *0.65*	**1**	**2.24** (0.43–11.70) *0.34*	**2.24** (0.21–23.52) *0.50*
4.3 × 8	**0.19** (0.01–3.96) *0.29*	**0.22** (0.01–4.53) *0.33*	**0.45** (0.09–2.33) *0.34*	**1**	**1**
3.5 × 10	**0.16** (0.06–4.14) *0.27*	**0.18** (0.01–4.74) *0.30*	**0.45** (0.04–4.68) *0.50*	**1**	**1**

N.B.: Odds ratio of success in favour of the row item. Read data as OR (in bold letters), 95% C.I. (in brackets) and *p-value* (in italics) from above downwards.

Table 5 Odds ratios of survival based on implant site.

Implant site*	UCI	ULI	U2ndP	LI	LP
UCI	**1**	**1.32** (0.17–10.03) *0.79*	**0.47** (0.04–5.45) *0.55*	**0.32** (0.03–3.64) *0.36*	**0.79** (0.07–9.22) *0.85*
ULI	**0.76** (0.10–5.76) *0.79*	**1**	**0.36** (0.03–4.16) *0.41*	**0.24** (0.02–2.78) *0.25*	**0.59** (0.05–7.03) *0.68*
U2ndP	**2.12** (0.18–24.51) *0.55*	**2.80** (0.24–32.60) *0.41*	**1**	**0.67** (0.67–11.12) *0.78*	**1.67** (0.10–28.09) *0.72*
LI	**3.15** (0.27–36.15) *0.36*	**4.16** (0.36–48.08) *0.25*	**1.49** (0.09–24.55) *0.78*	**1**	**2.48** (0.15–41.45) *0.52*
LP	**1.27** (0.11–14.93) *0.85*	**1.68** (0.14–19.85) *0.68*	**0.60** (0.04–10.11) *0.72*	**0.40** (0.02–6.76) *0.53*	**1**

N.B.: Odds ratio of success in favour of the row item. Read data as OR (in bold letters), 95% C.I. (in brackets) and *p-value* (in italics) from above downwards.

* UCI, upper central incisor; ULI, upper lateral incisor; U2ndP, upper 2nd premolar; LI, lower incisor; LP, lower premolar.

with survival rates of 97.6% and 100%, respectively. Both studies used implants with narrow diameters (range: 3–3.75 mm). In this study, when 72 immediate implants were placed in the mandible at the LI and LP extraction sites, only two implant failures occurred (overall survival rate of 97.3%). Both failures were associated with the 4.3 × 8 mm implants, suggesting that the failure could have been a result of inadequate buccal bone after preparation of the implant site, due to the larger diameter of the fixture.

Peri-implant bone resorption is a key factor influencing implant survival. Multiple authors seem to be in agreement about the minimal bone resorption associated with immediate implants (Cosyn et al., 2011; Degidi et al., 2012). All the implants in this study were evaluated clinically for stability and peri-implant disease throughout the follow-up period. Any residual gap between the socket wall and implant surface was filled with an autologous bone graft during implant placement. This approach has been reported to improve implant survival and to reduce marginal bone loss (Kahnberg, 2009). No attempt was made to assess the effect of the time of implant loading on implant survival because several studies have found no statistically significant relationship between these two variables (Esposito et al., 2013; Harel et al., 2013; Shibly et al., 2012). However, the implant loading time was comparable to that in a 5-year prospective clinical study by Botticelli et al. (2008), which reported an implant survival rate of 100%, good preservation of the marginal bone, and minimal peri-implant disease.

5. Conclusion

Immediate implant placement in fresh extraction sockets provides predictable anatomic, functional, and aesthetic outcomes. There is no conclusive evidence of any particular implant size or placement site that is more successful than any other.

Source of funding

NIL.

Ethical approval

Ethics committee at the College of Dentistry Research Center (CDRC), King Saud University, Riyadh, Saudi Arabia.

Conflict of interest

Authors declare that they have no conflict of interest/s related to the present study.

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