Evaluation of the Esthetic Results of 64 Nonfunctional Immediately Loaded Postextraction Implants in the Maxilla: Correlation between Interproximal Alveolar Crest and Soft Tissues at 3 Years of Follow-Up

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ABSTRACT

Purpose: Many authors have emphasized that immediate loading protocols enable better esthetic results to be achieved compared with delayed loading, especially in the case of postextraction implants that are capable of maintaining the original esthetics of soft tissues. The aim of this study was to establish correlations between the interproximal crest, interproximal papilla, and marginal facial gingiva of immediately loaded postextraction implants by evaluating clinical and radiographic data.

Materials and Methods: Fifty-eight consecutive patients underwent a tooth extraction and immediate implant placement with 64 postextraction implants, which were immediately loaded using a provisional single crown from June 2005 to December 2006. At 6 months after surgery, all implants were restored with a definitive single crown. Clinical and radiographic data were recorded at the time of surgery, at the time of definitive restoration, and after 3 years of functioning, in order to evaluate soft tissues esthetics and bone tissue condition. Statistical analysis was used to assess significant correlations between the interproximal crest, interproximal papilla, and marginal facial gingiva ($p = 0.05$).

Results: After 3 years of functioning, the implant success rate was 100% because no implants had failed. All parameters were stable and steady during the 3-year follow-up. The regression test revealed a statistically significant correlation between interproximal crest levels and interproximal papilla volume ($p = 0.0134$), and also between interproximal crest levels and marginal gingiva levels ($p = 0.0226$).

Conclusions: Postextraction immediately loaded implants represent a predictable technique that should be considered the treatment of choice in cases of single anterior tooth restoration and other cases. Esthetic results seem to depend on correct positioning of the implants, considering the correlation between bone tissue and related soft tissues. Maintaining the original condition of both bone and soft tissues around the tooth to be removed is the key to obtaining optimal esthetic outcomes.

KEY WORDS: esthetics, immediate loading, postextraction implants, soft tissue

INTRODUCTION

Anterior tooth loss is a true psychological trauma for the patient because it compromises self-confidence and self-image, with various consequences in terms of social relationships. In the past, the missing tooth could be replaced by one of three prosthodontic treatments:

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a conventional fixed bridge, a resin-bonded bridge, or a single-tooth implant.[1] The use of osseointegrated implants in dentistry has resulted in a significant improvement in the survival of single crowns and fixed partial dentures.[2]

Unfortunately, since prosthetic restoration of implants is a process involving a long waiting period, requiring 3 months for tooth socket healing and another 3 months for osseointegration, it is very difficult to satisfy the expectations of patients who ideally desire the immediate restoration of compromised teeth.[3,4]

Brånemark et al.[5,6] demonstrated that predictability of implant osseointegration could be considered possible, only thanks to an accurate surgical and prosthetic protocol in which a submerged insertion technique and a stress-free healing period were scheduled. Four months were necessary after extraction in order to limit the onset of infections and prevent epithelial growth in the implant sites.[7] The validity of this protocol is highlighted and confirmed by its widespread use in clinical practice and its success rates after a follow-up of over 10 years.

Since 1990, when Buser et al.[8] first indicated that 100 intentionally nonsubmerged implants yielded high predictability for successful tissue integration, many authors have reported encouraging results when applying one-stage protocols.

Innovations in implant surfaces and designs have permitted "positive" micromovements of the implants (i.e., micromovements inferior in extent to the tolerance threshold of the bone [2,000–4,000 µstrain]) that do not compromise the osseointegration process, especially in the case of immediate loading.[9–11]

Thus, in order to noticeably improve the patients' quality of life and to completely satisfy the patient's expectations, the possibility of drastically reducing the waiting time between insertion and functional restoration of the implants has prompted many authors to take an interest in the early and immediate loading of implants. By "immediate" we mean the application of loads and forces onto the implants immediately after their positioning or within 72 hours, while, by "early" we mean the application of loads and forces onto the implants after a time interval, which is less than the standard protocol waiting times.[12]

The most important application of the immediate loading protocol is to permit the clinician to treat edentulous patients, replacing immediately extracted teeth with an implant-supported crown. The great advantage is that it avoids the patient having to suffer psychological trauma and stress for the loss of a tooth because the tooth is instantly replaced. Wöhrle et al.[13] first reported 14 consecutive cases in which an immediate implant placement procedure was used for single-tooth restoration in the esthetic zone with immediate provisionalization.

Figure 1 Preoperative radiograph of fractured tooth.

Since 1998, many authors have reported encouraging results when applying immediate restoration protocols in fresh extraction sites, emphasizing the esthetic results achieved with these protocols.[14,15] The clinical and radiographic results of immediate restorations of dental implants placed in fresh extraction sockets were comparable with those obtained in delayed implants. No significant differences in outcome measures were reported in clinical trials comparing immediate, early, or conventional implant strategies; however, important parameters such as esthetic outcome, soft tissues aspects, and patient satisfaction were clearly underrated.[16]

Numerous authors have reported similar implant survival and success rates for implants inserted in the

Figure 2 Preoperative photograph of fractured tooth.

Figure 4 Postoperative photograph, after implant placement and abutment connection.

esthetic zone.[12,16–19] However, the current literature is limited when it comes to objective outcome evaluation from an esthetic point of view, as reported in several systematic reviews.[16,20] Recently, a constantly growing number of authors have attempted to objectively assess the esthetic outcome of single-tooth implants.[4,20–26]

Fürhauser et al.[24] introduced a new index to evaluate the esthetic aspect of soft tissue around implants, defined as the "pink esthetic score": it considers seven parameters that accurately describe all features of soft tissues.

Meijer et al.[27] suggested another index to objectively assess the esthetic outcome of single-tooth implant crowns, namely the "implant crown esthetic index," which includes measurements of the implant crown and related mucosa.

Recently, Belser et al.[26] proposed another index to completely evaluate the esthetics of implant restoration, called the "white esthetic score". The authors applied this score along with the pink esthetic score (PES) in order to evaluate the outcomes of early placed maxillary anterior single-tooth implants.

All studies based on the PES or other scores reveal a possible correlation between bone tissue and soft tissues due to the fact that interproximal and vestibular alveolar bone support the interproximal papilla and marginal gingiva, respectively.[4,20,23–26]

It is important to note that the most of the recent studies evaluating the esthetic outcome of immediately loaded postextraction implants have too short a follow-up to ensure with certainty that the outcome is maintained in the following years.[28–31]

The aims of the present study were two: (i) to evaluate any changes in bone and soft tissues as a result of the immediate loading of postextraction implants over a 3-year follow-up period and (ii) to establish the correlations between the interproximal crest, the interproximal papilla, and the marginal facial gingiva.

MATERIALS AND METHODS

Patients

The patients chosen for this study were referred to the Department of Dentistry and Maxillofacial Surgery of

Figure 3 Detail of residual root, after removal of fractured crown.

Figure 5 Detail of abutment, after connection.

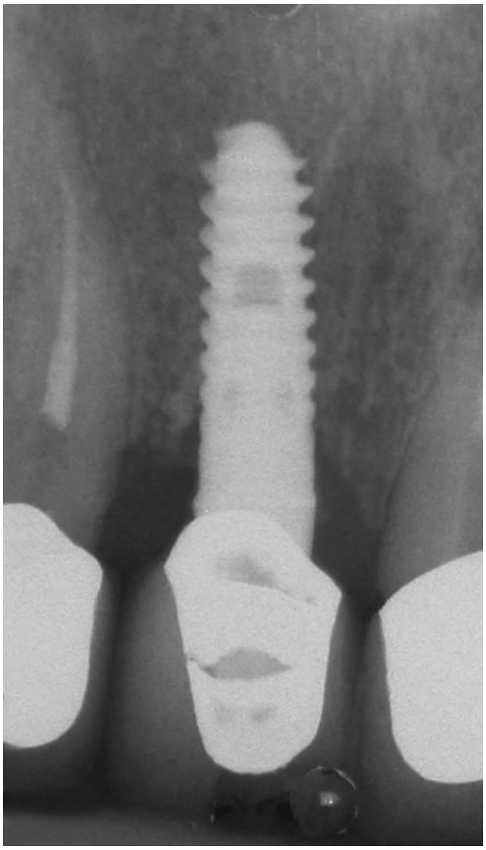


Figure 6 Postoperative radiograph of implant, after immediate loading.

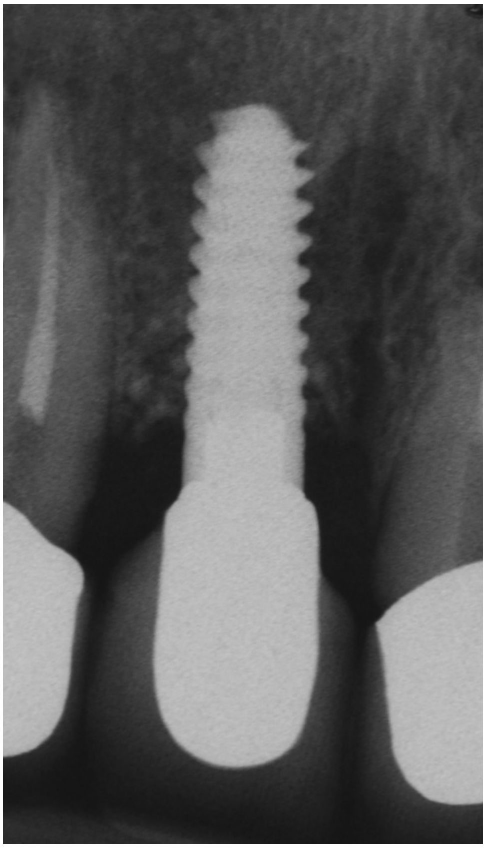


Figure 8 Radiographic examination of bone tissue, after 1-year follow-up.

the University of Verona for single implant-supported rehabilitation of the maxilla.

Fifty-eight patients of a cohort of 70 who had been treated consecutively from June 2005 to December 2006 were included in this prospective study. The study was conducted in accordance with the Helsinki Declaration of 1975, as revised in 2000, and all patients included had to sign an informed consent form.

The group consisted of 26 female and 32 male patients, with a mean age of 39.9 years (range: 19–78 years), who needed restoration of compromised teeth with a single-tooth implant in the maxilla.

The cohort of 70 patients was screened to identify only patients who met the following criteria: good oral hygiene and compliance; absence of chronic systemic pathologies; absence of bruxism or parafunctions; light

Figure 7 Postoperative photograph of provisional restoration, after immediate loading.

Figure 9 Clinical examination of soft tissues, after 1-year follow-up.

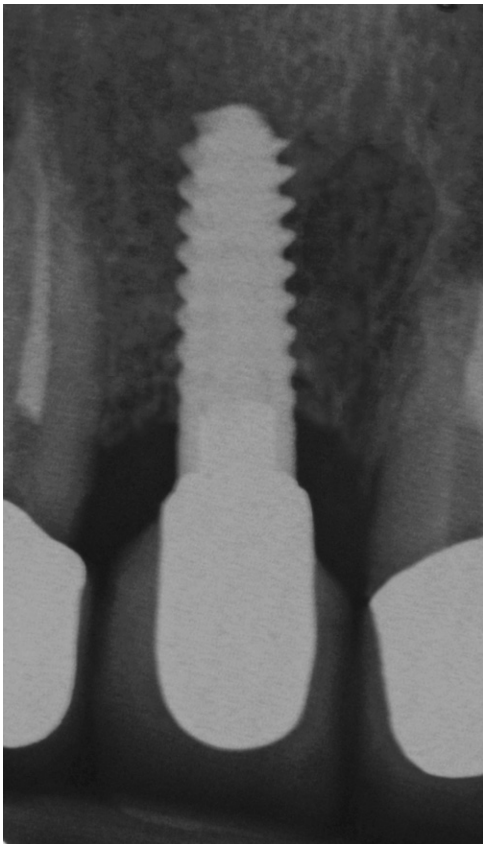


Figure 10 Radiographic examination of bone tissue, after 3-year follow-up.

or medium smoking habit (fewer than 20 cigarettes/day); normal or thick soft tissue biotype; width of keratinized mucosa ≥2 mm; maxillary tooth compromised by trauma, radicular fractures, radicular resorption, endodontic or periodontal treatment failures, destroying caries, or prosthetically nonrepairable crowns.

Figure 11 Clinical examination of soft tissues, after 3-year follow-up.

It should be noted that the presence of inflammatory lesions, due to endodontic or periodontal infections, was not considered an exclusion criterion.

Implant System

Implants were provided by the manufacturer and were purchased by the authors. A total of 64 implants were followed up in this study.

Fast bone regeneration (FBR)-coated implants were used. They have a surface coated with platelet-like bonded calcium phosphate (CaP) crystals that endows them with a high-submerging capacity and a marked capillary effect that facilitates osteogenetic bonding.

The FBR surface consists of 100% CaP, which is additionally applied through electrochemical deposition on the tried-and-tested fine granular Vacuum–Titanium Plasma Spray (V-TPS) surface in a 15 to 20 µm bioactive layer, inducing formation of brushite ($Ca/p = 1.1$).

Implant diameters ranged from 3.25 to 4.9 mm, and implant length ranged from 10 to 16 mm.

All implants were inserted in postextractive sites in the anterior maxilla: 48 implants (75.0%) in the incisal region (12–22), and 16 implants (25.0%) in the canine region (13 and 23). Lastly, it should be pointed out that all implants were immediately loaded at the time of surgery, using provisional abutments and provisional single crowns. Definitive restorations were accomplished for all implants within 6 months of surgery.

Clinical and Prosthetic Protocols

All patients received a standardized treatment that consisted in the insertion of a postextraction implant and the immediate loading of the implant with a temporary resin crown. A single surgeon performed all the surgical procedures.

Definitive restoration with a metal-ceramic or zirconia-ceramic crown was accomplished about 6 months after surgery, in relation to patient's needs or laboratory work times. A single prosthodontist performed all the prosthetic procedures.

Clinical and radiographic examination focused respectively on the "smile line", intra-arch relationship, bucco-palatal width, biotype of soft tissues, condition of the compromised tooth and adjacent teeth; and mesiodistal width, inter-radicular distance, residual bone apically to the root apex, root anatomy of the compromised tooth and adjacent teeth.

The treatment alternatives were explained to the patient. The possibilities of single-stage surgery with a postextraction implant versus two-stage surgery with extraction and implant in healed sites after guided bone regeneration, and of immediate loading versus delayed loading of the implant were emphasized. Finally, informed consent for the accepted procedure was obtained from all the patients.

On the day of surgery, the patient received 3 g amoxicillin plus clavulanic acid 1 hour before surgery and 1.5 g amoxicillin plus clavulanic acid 8 hours after surgery to reduce the risk of infection; 2.0% chlorhexidrine digluconate mouth rinse, one application before surgery and one every 8 hours for 7 days; and a nonsteroidal anti-inflammatory drug to reduce any excessive inflammatory response.

The surgical protocol comprised atraumatic avulsion of the tooth using periotome and/or great caution to avoid fractures of buccal plate, without flap elevation (flapless technique); curettage of the alveolar socket for complete removal of inflammatory tissue; implant site preparation; and implant insertion.

The preparation of the implant site in anterior areas was oriented 15 to 20° in a palatine direction in order to obtain good primary stability; in posterior areas, it should be perpendicular to the occlusal plane. All the sites were prepared with osteotomes or drills depending on bone volume using the alveolar walls as guides.

The longest and widest possible implants were chosen and inserted in the prepared sites, maintaining them at a distance of not less than 3 mm from the adjacent teeth and at the most coronal part of the alveolar crest in order to obtain a favorable emergence profile and maximum preservation of interproximal bone. If needed, autogenous bone chips retrieved from drills were placed in the gap between the implant and the alveolar walls.

In order to correctly position the implant head and obtain optimal support for prosthetic restoration, a slight slope can be conferred on the implant, maintaining it axially aligned with the occlusal forces.

A titanium abutment was screwed on the implant, the occlusion was checked, and the required modifications were marked; it was removed from the implant and modified in height and angulation; finally, it was rescrewed in place with a torque of 20 N.

It should be noted that suitable precision of adaptation between prosthesis and abutment and a correct tightness of the junction screws are important factors. Furthermore, passivity of the implant-prosthesis components must always be achieved.

In the case of cemented provisional prostheses, a prefabricated acrylic resin crown was used and rebased on the previously modified abutment with acrylic resin, filling the gap between the crown and the abutment; the crown was then removed from the implant to refine and contour the surface profile in order to achieve proper adaptation of the gingival soft tissues.

The occlusion was adjusted to eliminate all contact in maximum intercuspation, or lateral and protrusive excursions: any occlusal contacts during centric and eccentric movements on the provisional restoration were eliminated. In nonfunctional immediate loading protocols, the implants were not positioned in occlusion, giving them a nonfunctional load, that is, equal to 10 kg/cm^2 for a maximum of 30 minutes per day.[32]

Finally, the provisional prosthesis was cemented onto the abutment to allow soft tissues maturation and to attempt implant osseointegration.

The patient was instructed to consume a soft diet and to avoid placing food in the surgical area during the first 6 weeks; he or she was also instructed to rinse twice daily with 0.2% chlorhexidrine digluconate and to avoid brushing the surgical site in the first 2 weeks.

After 6 months, the temporary crowns and abutments were removed. Transfer copings were inserted on the implant with a seating instrument and secured with abutment screws. Impressions were made with a polyether material, using an individual impression tray.

A definitive abutment was realized in the laboratory using a master model as reference and then screwed onto the implant with a torque of 32 N.

Finally, a definitive metal-ceramic or zirconia-ceramic crown was also prepared in the laboratory, conferring upon it the best possible esthetics: general tooth form, outline and volume of the clinical crown, color (hue and value), surface texture, translucency, characterization, and emergence profile were the most important factors considered for achieving a good esthetic outcome. The interproximal contact points of the definitive crown were realized at the same level as the contact points of the corresponding natural control tooth, thus ensuring a natural symmetrical and harmonious appearance.

The definitive crown was cemented onto the implant to complete the patient's rehabilitation. The patient was followed up monthly during the first 3 months and yearly over the following years.

Data Collection

A database was created from patient records for treatments completed from December 2005 to May 2007. Recorded data included: name and surname of patient (initials); site of extracted tooth; kind of implant site preparation; diameter and length of implant; soft tissues biotype; width of keratinized mucosa; date of implant insertion; date of functional loading; date of last clinical; and radiographic follow-up.

A thin biotype and a keratinized mucosa <2 mm were considered prejudicial to implant rehabilitation, in that the hard and soft tissues feedback proves less predictable because they does not offer adequate "protection" for the transmucous healing of the implants. Furthermore, a connective tissue graft is often necessary to guarantee a favorable esthetic result. It is therefore good policy to downgrade the thin biotype and the poor keratinized mucosa to a more traditional surgical intervention.

The periapical x-rays were always taken using customized occlusal templates associated to customized Rinn holder devices (RinnXCP Instrument Kit, Dentsply, Elgin, IL, USA) and standard long-cone paralleling techniques.

Presence of pain, dysesthesia, or paresthesia around the implant area, presence of peri-implant infection and/or suppuration, presence of perceptible implant mobility, presence of radiolucencies at the implant-bone junction, and marginal bone loss (MBL) measurements were also recorded in order to assess the success rate.

In each patient, MBL and interproximal crestal bone level (ICBL) were measured by examination of periapical x-rays, which were performed at the time of surgery, at the time of functional loading (baseline), and after 6 months, 1 year, and 3 years (follow-up).

The MBL measurements were carried out mesially and distally to each implant, calculating the difference between first bone-implant contact point at baseline and at follow-up: the first bone-implant contact point was defined as the distance between the shoulder of the implant and the most coronal point of contact between the bone and the implant. ICBL measurements were also carried out mesially and distally to each implant. ICBL was calculated as the distance between the interproximal crestal apex and the contact point with adjacent teeth, at the moment of tooth extraction. Both measurements were rounded off to the nearest 0.1 mm, with the help of a sevenfold magnifying lens. A peak scale loupe with a sevenfold magnifying factor and a 0.1 mm graduated scale was used, as described by Degidi et al.[19]

Moreover, in each patient, interproximal papilla levels (IPLs) and facial gingival margin levels (FGMLs) were measured by observation of clinical photographs, taken in a standardized manner using a modified facial bow, in order to have the same clinical view of the tooth and related soft tissues at the time of surgery, and after 6 months, 1 year, and 3 years. The levels at the time of surgery, that is to say after tooth extraction and implant placement, were used as reference points (baseline) to measure subsequent soft-tissue changes. The measurements were carried out on each implant, calculating the distance between the interproximal papilla apex and the contact point, and the distance between the facial gingival margin and the "ideal" facial gingival margin based on the corresponding natural control tooth. All these measurements were rounded off to the nearest 0.5 mm, using a periodontal probe and a 1 mm graduated scale.

Follow-Up and Success Evaluation

The 58 patients were called back every 6 to 9 months as part of their routine oral hygiene program during the follow-up period. A clinical and radiographic examination was carried out after 6 months, 1 year, and 3 years, according to the previously established study protocol.

Implant success was defined according to the criteria suggested by Buser et al.[33] and modified by Albrektsson et al.,[34] including: (i) absence of persistent pain, dysesthesia, or paresthesia in the implant area; (ii) absence of peri-implant infection with/without suppuration; (iii) absence of perceptible implant mobility; and (iv) absence of persistent peri-implant bone resorption greater than 1.5 mm during the first year of loading and 0.2 mm per year during the following years.

The implants were considered successful in the presence of all of the above-cited criteria at the most recent follow-up appointment. Clinical complications such as pain, dysesthesia, or paresthesia were assessed by interviews with the patients; peri-implant infection with/without suppuration and implant mobility were assessed by clinical observation and pressure; radiographic complications such as excessive peri-implant bone resorption or radiolucencies were assessed by periapical x-rays.

Statistical Analysis

All data were analyzed according to well-established statistical analyses (linear regression analysis). Statistical comparisons were carried out with a 0.05 statistical significance cutoff ($p = 0.05$) Thus, it was possible to evaluate the correlations, if any, between ICBL and IPL, and between ICBL and FGML, determining the presence or absence of statistically significant correlations between the three parameters.

Friedman's test was used to evaluate statistically significant differences in the three parameters at baseline and after 3 years of follow-up.

Fisher's exact test proved possible to compare the MBL of implants placed in sites prepared using osteotomes with those in sites prepared using drills, evaluating the presence or absence of statistically significant differences between the two kinds of implant site preparation.

Statistical comparisons were carried out according with a 0.05 significance cutoff ($p = 0.05$), that is, a p value < .05 was considered statistically significant.

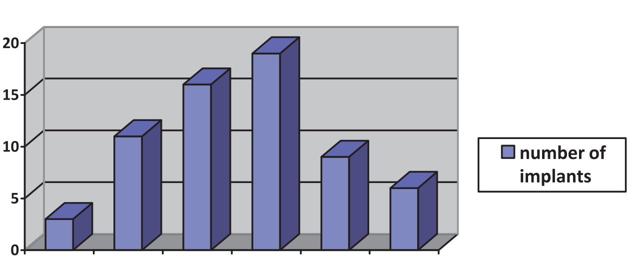
RESULTS

Evaluation of Success Rate

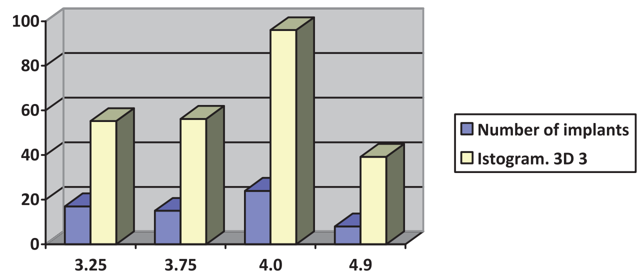
A total of 64 implant-supported single-crown prostheses were inserted in 58 patients to replace compromised teeth. The implant sites are reported in Graphic 1.

Mean implant length and mean implant diameter were 13.2 and 3.85 mm, respectively. The distributions of implants according to length and diameter were reported in Graphics 2 and 3.

No implants were lost or failed during the 3-year follow-up. All 64 maxillary single-tooth implants fulfilled the previously established success criteria, giving a 100% implant success rate. As a consequence, the prosthesis survival rate was 100%. None of the 58 patients dropped out during the study period.



Graphic 1 Distribution of implants according to site.



Graphic 2 Distribution of implants according to diameter.

Radiographic Evaluation of the ICBL

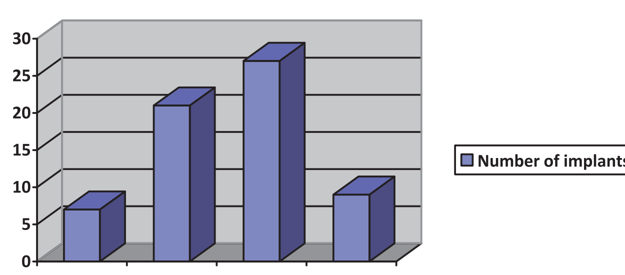
Most implants ($n = 30$) (46.9%) showed MBL ranging from 0.6 to 1.0 mm; 26 implants (40.6%) presented bone resorption between 0.1 and 0.5 mm; five implants (7.8%) had no bone resorption; and only three implants (4.7%) had a bone loss of more than 1.0 mm at 3 years of follow-up. None of the osseointegrated implants presented a mean MBL greater than 1.2 mm.

After 3 years' of follow-up, the mean MBL (average of the mesial and distal values) was 0.8 ± 0.6 mm (range: 0.0–1.2). The MBL was 0.7 ± 0.5 mm (range: 0.0–1.2) mesially and 0.9 ± 0.7 mm (range: 0.1–1.3) distally.

The ICBL measurements revealed that the mean values at baseline and at follow-up were 5.4 ± 0.9 (range: 3.8–6.9) and 5.6 ± 0.9 mm (range: 4.0–7.5), respectively; during the 3-year follow-up, the mean ICBL was 0.2 ± 0.3 mm (range: 0.0–1.1). There was no difference in crestal remodeling during the 3 years of follow-up, when comparing ICBL at baseline versus ICBL after follow-up ($p = 0.0492$).

Most of the implants showed no bone resorption of the interproximal crest ($n = 25$) (39.1%) or bone resorption ranging from 0.1 to 0.5 mm ($n = 27$) (42.2%); 11 implants (17.2%) presented bone loss ranging from 0.6 to 1.0 mm; and only one implant (1.6%) had a bone loss of more than 1.0 mm at 3 years of follow-up.

At baseline, three implants (4.7%) had an ICBL value less than 4.0 mm; 19 implants (29.7%) presented



Graphic 3 Distribution of implants according to length.

ICBL values ranging from 4.0 to 4.9 mm; in the case of 24 implants (37.5%), ICBL values were between 5.0 and 5.9 mm; and 18 implants (28.1%) had an ICBL value between 6.0 and 6.9 mm.

At 3 years' of follow-up, 19 implants (29.7%) had an ICBL value ranging from 4.0 to 4.9 mm; 21 implants (32.8%) presented ICBL values ranging from 5.0 to 5.9 mm; in the case of 21 implants (32.8%), ICBL values ranged from 6.0 to 6.9 mm, and only three implants (4.7%) had an ICBL value equal to or greater than 7.0 mm.

The detailed results of the radiographic evaluation of all the 64 single-tooth implants examined are reported in Table 1, whereas the distributions of implants according to the parameters evaluated are presented in Graphic 4.

Clinical Evaluation of IPL and FGML

The detailed values of the 64 examined single-tooth implants are presented in Table 2, whereas the distribution of implants according to IPL and FGML are shown in Graphic 5.

As regards IPL, the mean value of the distance between the interproximal papilla apex and the contact point was 0.7 ± 0.6 mm (range: 0.0–2.0). The IPL was 0.6 ± 0.5 mm (range: 0.0–2.0) mesially and 0.8 ± 0.6 mm (range: 0.0–2.0) distally. The distribution of implants based on IPL revealed that most implants ($n = 32$) (50.0%) showed IPL values equal to or less than 0.5 mm, and 22 implants (34.4%) had an IPL value of 0.0 mm; 18 implants (28.1%) presented IPL values of 1.0 mm; 10 implants (15.6%) had IPL values of 1.5 mm; and only four implants (6.3%) had an IPL value equal to 2.0 mm.

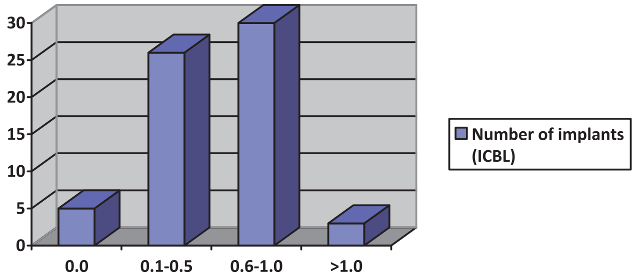
As regards FGML, the evaluation of soft tissues showed that the mean distance between the facial gingival margin and the "ideal" facial gingival margin was 0.5 ± 0.6 mm (range: 0.0–2.5). Most of the implants ($n = 30$) (46.9%) presented no discrepancy because of an FGML value of 0.0 mm; 14 implants (21.9%) had FGML values of 0.5 mm; 12 implants (18.8%) had FGML values of 1.0 mm; and only eight implants (12.5%) had an FGML value equal to or greater than 1.5 mm.

Statistical Analysis

The linear regression analysis revealed statistically significant correlations between ICBL and IPL ($p = 0.0134$)

TABLE 1 Interproximal Crestal Bone Level (ICBL) of All 64 Implants

n°	ICBL at Baseline	ICBL at Follow-Up	ICBL Modification
1	5,10	5,10	0,00
2	6,80	6,90	0,10
3	6,30	6,40	0,00
4	5,70	5,70	0,00
5	4,10	4,10	0,00
6	6,30	6,80	0,50
7	4,00	4,00	0,00
8	5,80	6,50	0,70
9	6,10	6,30	0,20
10	5,70	6,30	0,60
11	3,80	4,10	0,30
12	6,60	6,60	0,00
13	4,70	4,90	0,20
14	4,20	4,30	0,10
15	5,70	6,00	0,30
16	4,90	4,90	0,00
17	5,00	5,70	0,70
18	4,80	4,80	0,00
19	6,50	6,50	0,00
20	4,50	5,10	0,60
21	5,30	5,50	0,20
22	5,50	5,70	0,20
23	4,30	5,00	0,70
24	6,70	7,50	0,80
25	6,10	6,50	0,40
26	4,40	4,40	0,00
27	6,40	6,90	0,50
28	5,60	5,80	0,20
29	5,80	6,40	0,60
30	5,60	5,60	0,00
31	5,90	6,30	0,40
32	5,70	5,70	0,00
33	3,90	4,00	0,10
34	6,40	6,50	0,10
35	4,00	4,00	0,00
36	5,60	5,60	0,00
37	4,50	4,70	0,20
38	5,80	5,90	0,10
39	5,40	5,40	0,00
40	4,90	5,20	0,30
41	6,10	6,10	0,00
42	5,70	5,80	0,10
43	6,90	6,90	0,00
44	6,30	7,10	0,80
45	4,90	4,90	0,00
46	4,40	4,70	0,30
47	5,50	6,00	0,50
48	6,10	6,50	0,40
49	6,50	6,50	0,00
50	5,90	5,90	0,00
51	4,80	4,90	0,10
52	4,90	4,90	0,00
53	5,00	5,70	0,70
54	5,20	5,20	0,00
55	5,00	5,50	0,50
56	4,10	4,20	0,10
57	4,30	4,70	0,40
58	4,10	4,90	0,80
59	5,80	5,80	0,00
60	3,90	4,50	0,60
61	6,30	7,40	1,10
62	6,50	6,50	0,00
63	5,00	5,10	0,10
64	6,80	6,80	0,00



Graphic 4 Distribution of implants according to ICBL modification (mm). ICBL = interproximal crestal bone level.

and between ICBL and FGML ($p = 0.0226$). This means that an increase in the distance between the interproximal bone crest and the corresponding contact point can lead to a decrease in soft-tissue esthetics because of an increase in the distance between the interproximal papilla and the corresponding contact point and the discrepancy between the facial gingival margin and the "ideal" facial gingival margin.

However, Friedman's test revealed no statistically significant difference in crestal remodeling during the 3 years of follow-up, when comparing ICBL at baseline versus ICBL after follow-up ($p = 0.0492$).

The MBL of implants placed in sites prepared using osteotomes and drills were 0.8 ± 0.7 mm and 0.7 ± 0.8, respectively. Statistical analysis has revealed no significant difference between the two kinds of implant site preparation, the p value being 0.47 ($p > 0.05$).

DISCUSSION

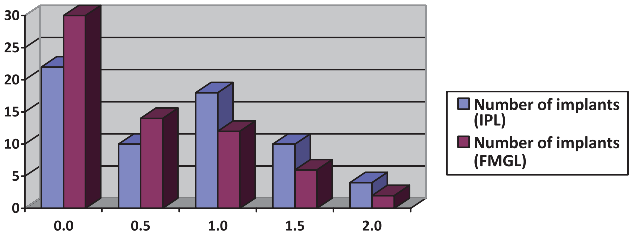
This prospective study presents the esthetic outcomes of 64 anterior maxillary single-tooth implants inserted according to the concepts of immediate postextractive placement and immediate loading of implants.

Since 1998, when Wöhrle[13] first reported 14 consecutive cases in which an immediate implant placement procedure was used for single-tooth restoration in the esthetic zone with immediate provisionalization, several authors have reported encouraging results when applying immediate restoration protocols in fresh extraction sites.[14,15,35,36]

The predictability of these techniques was demonstrated in the present study by the very high 100% implant success rate according to the previously established success criteria.[33,34] Similar success rates were reported by a number of authors who investigated the success of implants immediately placed in postextractive sites and immediately loaded with provisional crowns.[26,37–40]

TABLE 2 Interproximal Papilla Level (IPL) and Facial Gingival Margin Level (FGML) of All 64 Implants

n°	IPL at Follow-Up	FGML at Follow-Up
1	1,00	0,00
2	1,50	0,50
3	0,50	1,00
4	0,00	0,00
5	0,00	0,00
6	1,00	1,50
7	0,00	0,00
8	1,50	0,00
9	1,00	0,00
10	1,00	1,50
11	0,50	0,00
12	2,00	1,50
13	1,00	0,00
14	0,00	0,00
15	1,00	1,00
16	0,00	0,00
17	1,00	1,00
18	0,00	0,00
19	1,00	1,00
20	0,00	0,00
21	0,00	1,00
22	1,00	0,50
23	0,00	0,00
24	2,00	2,50
25	1,50	0,00
26	0,50	0,00
27	1,00	1,00
28	1,00	0,00
29	1,00	1,00
30	1,00	0,00
31	1,50	0,50
32	1,50	0,00
33	0,00	0,00
34	1,00	0,50
35	0,00	0,00
36	0,00	0,50
37	0,00	0,00
38	1,00	1,00
39	1,00	0,00
40	0,50	0,00
41	0,00	0,50
42	1,00	0,50
43	1,50	1,50
44	1,50	2,00
45	0,00	0,50
46	0,50	0,50
47	1,50	0,00
48	1,50	1,50
49	0,00	0,00
50	1,00	0,00
51	0,00	0,00
52	1,00	0,50
53	1,50	1,00
54	0,00	1,00
55	0,00	0,00
56	0,00	0,00
57	0,00	0,00
58	0,50	0,00
59	0,00	0,50
60	0,50	0,00
61	2,00	1,50
62	1,00	1,00
63	0,50	0,50
64	2,00	1,00



Graphic 5 Distribution of implants according to IPL and FGML modification (mm). FGML = facial gingival margin level; IPL = interproximal papilla level.

Although many authors have reported success rates in their studies, there have been few studies that objectively describe the esthetics of soft tissues. The preservation or creation of harmonious soft tissues contours of the peri-implant mucosa, with distinct papillae, might be the most important factor for obtaining favorable esthetic results after implant treatment.[41,42]

A recent study by Belser et al.[26] has illustrated the esthetic outcomes of immediately loaded postextraction implants, using the PES and the white esthetic score. Theirs, however, was a retrospective case-series study. In our study, the prospective design permitted us to describe soft and hard tissues maintenance in the follow-up period, to establish any correlations between ICBL and IPL and between ICBL and FGML, and above all to evaluate the esthetics of implant-prosthetic rehabilitation primarily influenced by soft tissues pattern.

The immediate placement and loading of implants was found to be an affordable technique for achieving favorable results. IPLs and FGMLs were optimal in most cases, considering that in the case of 78.1% of the implants, the distance between the interproximal papilla apex and the contact point was equal to or less than 1 mm, and in the case of 87.5% of the implants, the discrepancy between the facial gingival margin and the "ideal" facial gingival margin based on the corresponding natural control tooth was equal to or less than 1 mm.

The peri-implant IPL and FGML depend primarily on the ICBL, which was influenced by the alveolar bone height at the root surfaces of adjacent teeth, as shown in other clinical studies.[22,23,41] The statistical analysis of our study confirmed a statistically significant correlation between bone levels and soft tissue levels, demonstrating that the preservation of peri-implant bone is one of the most important factors for achieving good esthetic outcomes.

Recently, Kwon et al.[43] showed that the tooth-side bone level was the dominant factor affecting the interproximal soft tissues between a natural tooth and a single implant. Thus, preserving the alveolar bone on the interproximal side is of the utmost importance from an esthetic point of view.

Excellent marginal bone preservation and excellent esthetics can be achieved by means of immediate placement and loading of implants in postextractive sites.[44]

Although many authors have revealed no significant differences in interproximal crestal bone response to immediate versus delayed placement of implants, De Rouck et al.[45] and other authors[46,47] have suggested using immediate placement and immediate provisionalization techniques in order to preserve soft tissues and optimize the outcome of esthetic treatment.

The influence of immediate loading of postextraction implants on the aspect of the interproximal and facial soft tissues in single-implant restorations was evaluated after 3 years of follow-up. Many studies have reported results after a 1-year follow-up, but soft tissues may change in the following years because of crestal bone remodeling. In our study, however, crestal bone loss during follow-up was not statistically significant.[36,48,49]

Finally, one limitation of this study may be failure to achieve adequate statistical power, in view of the small number of implants, but this was offset by the maximum homogeneity of values due to the absence of appreciable differences in means and standard deviations of the parameters analyzed. However, it may be constructive to proceed with this line of research, increasing the number of cases included in this study, in order to detect clinical differences.

CONCLUSIONS

The use of an immediate loading postextractive protocol can be considered a predictable technique for achieving good esthetic results in the anterior maxilla.

The persistence of the interproximal crest seems to be the key point for maintaining ideal soft-tissue conditions. According to the data reported, the interproximal crestal bone shows a statistically significant correlation with the IPL and FGML, which are the most important factors for esthetic outcome.

The clinician should make every possible effort to prevent interproximal crestal bone loss in order to achieve the best possible esthetic outcomes: postextraction implants and their immediate loading should be considered in cases of single-tooth restoration.

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