Immediate Maxillary Restoration of Single-Tooth Implants Using Platform Switching for Crestal Bone Preservation: A 12-Month Study

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Purpose: *The aim of this prospective clinical study was to evaluate the survival rates at 12 months of a new implant design placed in the anterior and premolar areas of the maxilla and immediately restored with single crowns. Crestal bone loss was also assessed.* ***Materials and Methods:*** *Patients seeking replacement of at least one failing maxillary tooth were recruited to participate in the study. Exclusion criteria included compromised general health conditions, severe maxillomandibular skeletal discrepancies, severe parafunctional habits, drug or alcohol abuse, poor oral hygiene, and a need for bone augmentation. Implants incorporating the platform-switching concept were placed into fresh extraction sockets in the maxilla, with each patient receiving a provisional restoration immediately after implant placement. After 15 days, definitive restorations were inserted. Mesial and distal bone levels were evaluated with digital radiography on the day after implant placement, 15 days later, and 1, 2, 3, 6, 8, and 12 months later. Primary stability was measured with resonance frequency analysis (RFA). Analysis of variance for repeated measures and a binary logistic regression model were used to assess the data.* ***Results:*** *Sixty-one implants were placed into fresh extraction sites in 25 men and 25 women ranging in age from 29 to 51 years (mean, 39.64 ± 6.06 years). One of the implants failed, and one was lost to follow-up. The mean bone loss measured on the mesial was 0.08 mm (SD 0.53 mm). Mean distal bone loss was 0.09 mm (SD 0.65 mm). Over the course of 12 months, the mean RFA value between baseline and 12 months was 71.1 ± 6.2.* ***Conclusions:*** *The implants remained stable over the course of 12 months and had an overall survival rate of 96.7%. Minimal crestal bone loss was recorded around the surviving implants.* Int J Oral Maxillofac Implants 2009;24:275–281

Key words: *immediate provisionalization, platform switching, resonance frequency analysis*

Because high success rates have been achieved consistently when endosseous implants were placed in partially and completely edentulous patients, clinicians have begun to offer selected patients immediate and early implant placement options. The long-term success of immediately loaded implants has been investigated in animals[1,2] and humans,[3] with encouraging results. However, most of the studies have been performed with implants placed in the anterior mandible, where proper initial implant stability can be easily achieved.

In the anterior maxilla, clinicians seeking to load implants immediately must be concerned not only about achieving adequate implant stability, but also about fulfilling patients' desires for esthetic results that resemble the natural dentition. To achieve an optimal esthetic result, it is essential to maintain as much of the circumferential bone height around the implant neck as possible, controlling the biologic width.[4]

However, when an abutment is connected to a dental implant at the crestal level, bone loss around the implant always occurs. It has been demonstrated that the gap between the implant and the abutment has a direct effect on bone loss, regardless of whether the two parts are connected at the time of

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implant placement or after initial submergence and integration of the implant.[5] This phenomenon occurs whether the implant is loaded or unloaded and appears to be unrelated to the type of implant surface.[5,6] Hermann et al demonstrated that crestal bone remodels to a level about 2.0 mm apical to the implant-abutment junction (IAJ),[5,7,8] but Lazzara and Porter reported crestal bone levels about 1.5 to 2 mm below the IAJ at 1 year after restoration.[9] Tarnow et al have documented a horizontal component that results in 1.3 to 1.4 mm of resorption from the IAJ to the bone in a horizontal direction.[10,11] When the biologic width is reestablished in the wake of such osseous changes, the soft tissue architecture, including the appearance of the papillae, is affected. The interproximal height of bone influences the interdental papillae by acting as a guidepost for the soft tissue contours.

In addition to several ideas to limit crestal bone resorption, the concept of platform switching appears to be promising. Platform switching refers to the use of a smaller-diameter abutment on a larger-diameter implant collar. Such a connection shifts the perimeter of the IAJ inward toward the central axis of the implant.[12,13]

The aim of the present prospective clinical study was to evaluate the survival rate at 12 months for single platform-switched implants placed in the anterior and medial maxilla and immediately restored, as well as to assess horizontal crestal bone loss occurring around those implants.

MATERIALS AND METHODS

The research protocol called for recruitment of subjects from patients referred to the Department of General Dentistry, University of Murcia, Spain, during an 18-month period. All those in need of anterior oral rehabilitation that would include single implant placement were invited to take part in the study, which was overseen by the institutional review board.

Additional criteria for entering the study included sufficient bone height and width to allow the placement of implants with a minimum diameter of 4.1 mm and a minimum length of 10 mm, and an occlusal pattern that allowed for bilateral stability. All study subjects also needed to have at least 3 mm of soft tissue (vertically) to allow for the establishment of an adequate biologic width and to reduce bone resorption. Exclusion criteria included severe maxillomandibular skeletal discrepancies, uncontrolled diabetes, hemophilia, metabolic bone disorders, a history of renal failure or radiation treatment to the head or neck region, current chemotherapy, pregnancy, drug or alcohol abuse, poor oral hygiene, insufficient bone volume at the recipient site, and the need for bone augmentation procedures prior to implant placement.

The protocol called for placement of Certain Prevail implants (Biomet/3i, Palm Beach Gardens, FL). Unlike Certain parallel-walled implants, the 4-mm Certain Prevail implant body expands at the coronal aspect, resulting in a collar diameter of 4.8 mm. This expanded collar shape is beneficial since it can improve the sealing of immediate extraction sockets, as well as better engage the bone crest and provide better primary stability. The Certain Prevail design also incorporates an Osseotite surface (which is dual acid–etched) all the way to the top of the collar, providing a roughened bone-loading surface and allowing maximum bone-to-implant contact.

Restoration of the 4.8-mm implant collar with the corresponding 4.1-mm prosthetic abutment shifts the IAJ inward. Although the precise dimensions of this implant/abutment configuration are 4 mm (implant body)/4.8 mm (collar)/4.1 mm (platform), the manufacturer refers to it as a 4/5/4 implant. (A wider implant/abutment configuration whose actual dimensions are 5 mm [body]/5.8 mm [collar]/5 mm [platform] is referred to as the 5/6/5 implant.)

All surgeries were performed under local anesthesia, following the manufacturer's protocol. Sulcus incisions were made at the buccal and lingual part of the teeth. As a rule, implants were placed at a distance of 1 mm from the buccal plate. Implant stability was confirmed with resonance frequency analysis (RFA) measurements (Osstell Mentor, Integration Diagnostics, Göteborg, Sweden), used according to the manufacturer's recommendations. The intent was that if any of the initial implant stability quotient (ISQ) values were under 60, those implants would not be included in the study.[14]

After implant placement and suturing, each patient received 1 g of amoxicillin/clavulanic acid 500/125 to be taken twice daily for 7 days, 600 mg ibuprofen to be taken as needed, and a chlorhexidine mouthwash 0.12% for use twice daily for 2 weeks. Gentle brushing with a chlorhexidine toothpaste was recommended. Sutures were removed 8 to 10 days after surgery.

The initial restorative treatment began immediately following implant placement, while each patient was still under local anesthesia. An impression was made using a polyether rubber material (Impregum; 3M, St Paul, Minnesota) with a customized impression tray. A provisional abutment was then connected to the implant before the wound was closed with sutures. Within 24 hours after implant placement, a provisional cement-retained

acrylic resin crown or the patient's modified extracted tooth was connected to the provisional abutment (Fig 1). A digital periapical radiograph was obtained of each implant; to ensure parallelism and standardization for future comparison, a bite block was prepared for each patient and a paralleling technique used.

Radiographs were taken at the time of abutment connection (day 1), at 15 days postoperative, and at 1, 2, 3, 6, 8, and 12 months postoperative, in accordance with the following protocol. To ensure standardization of the radiographs, a Kodak RVG 6100 digital radiography sensor (Eastman Kodak, Rochester, NY) was kept parallel, and the x-ray beam (Heliodent MD, 60kV, 7mA; Siemens, Bensheim, Germany) was kept perpendicular to the implant. The radiographs were obtained using individually fabricated film holders (Have-Super-Bite, Hawe-Neos Dental, Genilini, Switzerland) attached to the occlusal surface of the superstructure with acrylic resin. Each radiographic image was labeled with the patient study identification number, date, length and diameter of implant placed, and tooth site.

For each implant, the radiographs were used to evaluate marginal bone height over time and bone-implant contact, with the aim of detecting any loss of osseointegration. The marginal bone height was determined at the mesial and distal surfaces of each implant by measuring the distance between the reference point (the implant shoulder) and the marginal bone-to-implant contact level using a magnifying (7×) lens. The error method of Wennström et al[15] was used to assess the radiographic marginal bone height.

Clinical evaluation of each patient also occurred on the day after implant placement (baseline), at 15 days, and at 1, 2, 3, 6, 8, and 12 months. Clinical parameters measured included the following:

- Width of keratinized mucosa, measured in millimeters at the midbuccal aspect
- Implant stability, as evaluated using the ISQ value obtained with the Osstell Mentor device
- Presence or absence of suppuration
- Probing depth

Fifteen days after implant placement, the provisional acrylic resin crowns or modified teeth were retrieved, and the final lab-prepared GingiHue Post or Provide Abutments (Biomet/3i) were connected to the implants and torqued to 20 Ncm. The definitive porcelain crowns were then cemented.

Data Analysis

Evaluation of all the data (means and medians) was done using SPSS 14.0 (SPSS Inc, Chicago, IL) software, with mean values, standard deviations, and cumulative frequencies calculated. The primary outcome variables were implant loss and peri-implant bone level change. Clinical data were considered as descriptors. The peri-implant bone level data were analyzed at the implant level. All statistical analyses were performed with the subject as the statistical unit. Analysis of variance for repeated measures was used for statistical analysis of changes in peri-implant bone level over 12 months of function. A binary logistic regression model, based on the case of "bone loss of > 0.5 mm" from baseline (day 1) to the 12-month follow-up exam, was formulated to analyze possible interactions with various characteristics of the subjects (age, gender, smoking habits) and implants (anterior/posterior location, length). For all analyses, a P value < .05 was considered statistically significant.

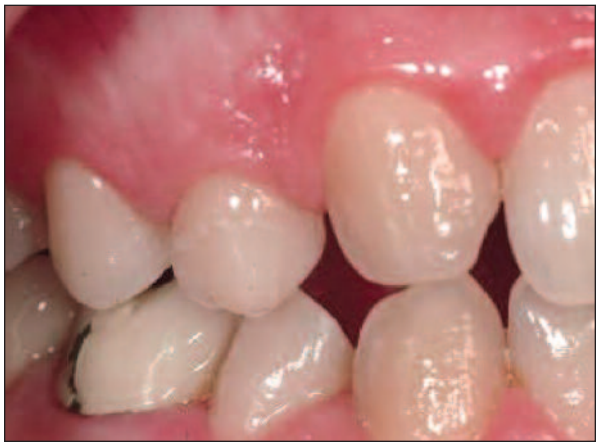

Fig 1 Lateral view of small provisional canine.

RESULTS

After receiving information about treatment options for replacing failing teeth, 50 patients (25 men and 25 women) who met the inclusion criteria provided informed consent to participate in the study. Reasons for their tooth extractions included sports trauma (n = 12), vertical fracture (n = 18), endodontic fracture (n = 12), and horizontal tooth fracture 5 mm apical to the crestal bone level (n = 19). Thirty-four subjects had thick tissue biotypes and 16 had thin tissue biotypes.

The mean age at the time of recruitment was 39.64 years (SD 6.06). Twelve of the patients were smokers, with a daily consumption of between two and 15 cigarettes. A careful dental/periodontal

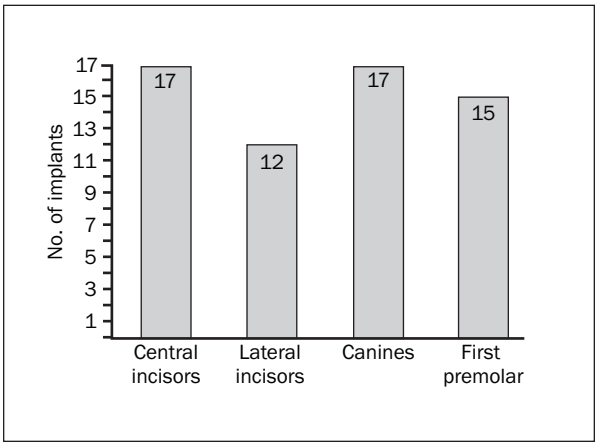

Fig 2 Distribution of implants placed (n = 61), according to positions in the maxilla.

examination was performed on each subject, including assessment of plaque, gingivitis, pocket depths, and radiographic bone loss involving all the remaining teeth. This was followed by oral hygiene instruction and periodontal therapy, if indicated.

After each failing tooth was extracted, a Certain Prevail implant was placed. Eleven patients received two implants, and 39 patients received one implant each, bringing the total number of implants placed to 61. All implants were placed in the maxilla, with 29 in the incisor region, 17 in the canine region, and 15 in the first premolar region (Fig 2).

Among the 61 implants placed, 25 were 4/5/4 mm in diameter and 13 mm long, 11 were 4/5/4 mm in diameter and 15 mm long, 11 were 5/6/5 mm in diameter and 13 mm long, and 14 were 5/6/5 mm in diameter and 15 mm long. The 12 lateral incisor sites included in the study received 10 implants that were 4/5/4 mm in diameter and 13 mm long and two that were 4/5/4 mm in diameter and 15 mm long. The 17 central incisor sites received five implants that were 4/5/4 mm in diameter; four were 13 mm long and one was 15 mm long. Of the 12 wider implants placed in the central incisor sites, six were 13 mm long, and six were 15 mm long. The 17 canine sites received 11 implants that were 4/5/4 mm in diameter. Of these, five were 13 mm long and six were 15 mm long. Two of the wider implants placed in the remaining canine sites were 13 mm long, and four were 15 mm long. The 15 first premolar sites received eight implants that were 4/5/4 mm in diameter; six were 13 mm long and two were 15 mm long. Wider implants were placed in the remaining seven first premolar sites; three were 13 mm long and four were 15 mm long. Table 1 summarizes the implant diameters and lengths employed.

At 14 implant sites (23%), a markedly reduced buccolingual hard tissue dimension was encountered. At these sites, implant placement resulted in a buccal bone dehiscence varying in depth from 1 to 5 mm. No attempts were made to augment the bone at these dehiscence sites.

The initial RFA demonstrated that all implants were clinically stable at the time of placement.

One implant, replacing a right first premolar, was removed after 4 months because of loss of osseointegration in a patient who was a heavy bruxer. Another implant (placed in a left first premolar site) could not be accounted for because the patient failed to show up for the 12-month follow-up examination. No other subjects were lost to follow-up, and the other 59 implants all remained clinically functional throughout the study. The overall survival rate at 12 months was thus 96.7%.

Minor complications occurred in eight patients, who each experienced a single incident of crown-cement loosening after crown placement. Furthermore, in two patients (one central incisor and one canine) 1.5 mm of soft tissue buccal recession was observed at the 6-month follow-up. Both of those patients had a thin gingival biotype, and in both case the implants were wider (5/6/5 Prevails).

Radiographic and Clinical Findings

The mean distance from the implant collar to the alveolar bone crest, measured on the mesial, was 3.57 mm on the day after implant placement and 3.65 mm 12 months later, a mean bone loss of only 0.08 mm. The mean off all the distal measurements was 3.49 mm the day after implant placement and 3.58 mm 12 months later, a 0.09-mm mean bone loss. The mean peri-implant bone level changes that occurred during the 12-month follow up period are described in Table 2.

The mean value of the implant bone measurements was 2.1 ± 0.5 mm at baseline and 2.4 ± 0.5 mm at the 12-month follow-up. The mean ISQ value (± SD) was 71.1 ± 6.2 at baseline and 75.8 ± 6.9 at 12-month follow-up. The mean value of keratinized mucosa, measured at the middle third of the buccal mucosa on each implant, was 3.4 ± 0.6 mm at baseline and 3.1 ± 0.5 mm at 12-month follow-up (Table 3). The differences in these results were not statistically significant.

All patients maintained a high standard of oral hygiene throughout the 12-month study period. Plaque was found on only 9% of all implant-abutment surfaces. Except for the single implant that failed to osseointegrate and was removed, no implant exhibited mobility.

The mean probing depth recorded at all sites on all the visits throughout the study varied from 3.0 mm at

Table 1 Implant Lengths, Diameters, and Locations

Implant size (w × l) (mm)	Central incisors	Lateral incisors	Canines	First premolars	Totals
4/5/4 × 13	4	10	5	6	25
4/5/4 × 15	1	2	6	2	11
5/6/5 × 13	6	0	2	3	11
5/6/5 × 15	6	0	4	4	14
Totals	17	12	17	15	61

Table 2 Mean Bone Level Changes (± SDs) from the Time of Crown Placement

Time	Mesial bone level	Distal bone level
Baseline	3.57 ± 1.1 mm	3.49 ± 0.8 mm
Day 15	3.57 ± 1.1 mm	3.49 ± 0.8 mm
1 mo	3.60 ± 1.2 mm	3.51 ± 0.6 mm
3 mo	3.63 ± 1.3 mm	3.54 ± 0.6 mm
6 mo	3.65 ± 1.5 mm	3.58 ± 0.7 mm
12 mo	3.65 ± 1.5 mm	3.58 ± 0.7 mm
Mean	0.08 ± 0.53 mm	0.09 ± 0.65 mm

Table 3 Clinical Measurements over 12 Months of Follow-up

Parameter	Baseline mean (SD)	12-month mean (SD)	*P*
Implant bone measurement	2.1 (0.5)	2.4 (0.5)	> .06
Implant stability quotient	71.1 (6.2)	75.8 (6.9)	< .05*
Keratinized mucosa	3.4 (0.6)	3.1 (0.5)	> .08

The differences in RFA values were statistically significant $P < .05$.

Table 4 Clinical Conditions at 12 Months (n = 59)

Mean probing depth	Buccal 3.0 mm (SD 0.8)	Lingual 3.4 mm (SD 1.2)	Proximal 3.7 mm (SD 0.87)
≤ 3 mm	83%	86%	65%
4–5 mm	17%	14%	23%
≥ 5 mm	-	-	12%

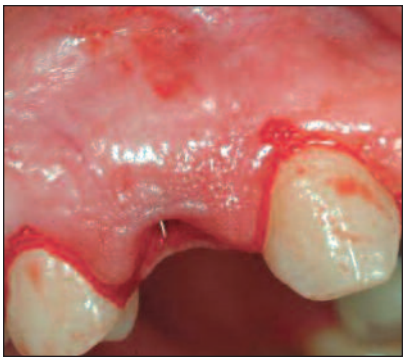

Fig 3 Flapless surgery for implant insertion.

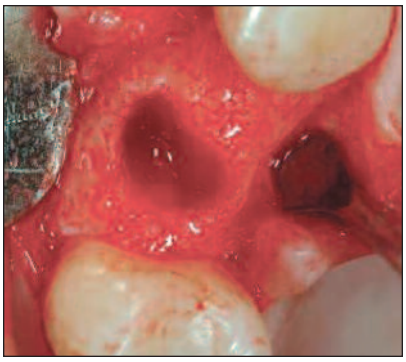

Fig 4 Mucoperiosteal flap reflection to observe the alveolar bone.

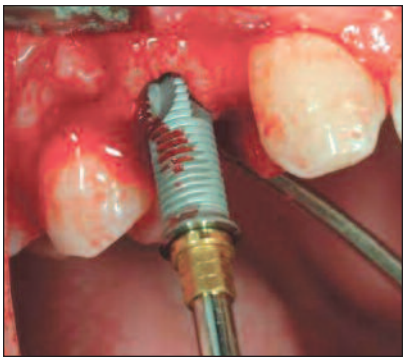

Fig 5 A 4/5/4 implant is introduced into the fresh extraction site.

buccal sites to 3.7 mm at proximal sites. About 80% of buccal and lingual peri-implant sites had a probing depth of < 3 mm, while at proximal sites the frequency was 67%. Some greater probing depths were found at proximal sites of implants that had been inserted deeply in relation to the bone level at the neighboring tooth surfaces and were not associated with peri-implant bone loss or lesions. At the annual examinations, the buccal and lingual probing depths at all implants were < 3 mm. (Table 4).

Figures 1 and 3 to 10 show the preoperative soft tissue conditions and the soft tissue, papillae, and bone levels at 12 months after surgery for one of the maxillary canines treated.

DISCUSSION

The present study confirms other preliminary evidence that bone loss commonly occurring around two-stage implants may be reduced or eliminated when implants are restored with smaller-diameter abutments on larger platforms.[12,16,17] This bone-preserving technique, known as platform switching, has been used for more than 10 years.[13] Research has demonstrated that, for two-stage implants, marginal bone loss occurs primarily during the first year following placement, and the main reason for this has been attributed to the generation of a biologic width adjacent to the implant.[5,7,8,18] Vela-Nebot et al

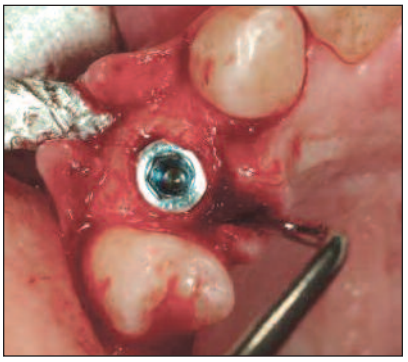

Fig 6 The implant is placed in the alveolar ridge, 1 mm palatal.

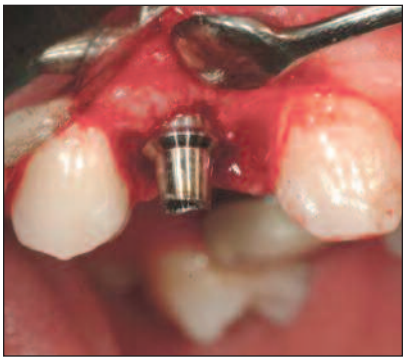

Fig 7 Provisional abutment torqued to 20 Ncm into internal connection.

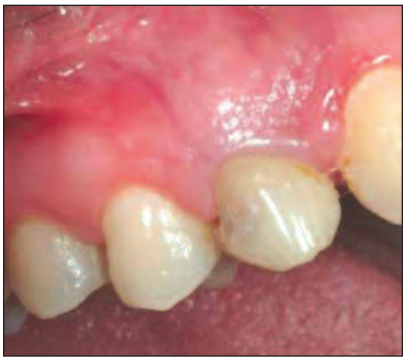

Fig 8 Patient's provisional maxillary right canine after 15 days of healing.

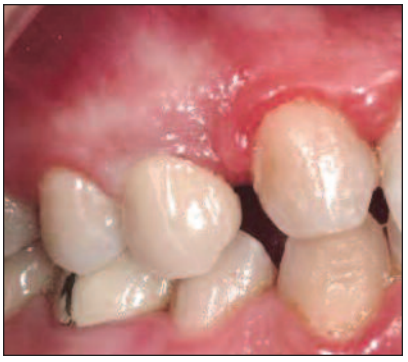

Fig 9 Definitive porcelain crown after 12 months.

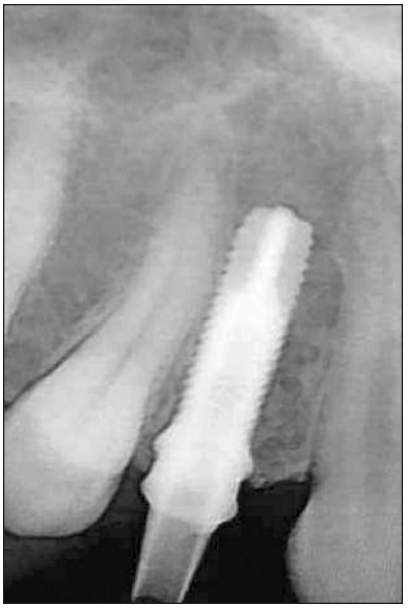

Fig 10 Digital periapical radiograph taken of the same implant at 12 months, with which the crestal bone levels on the mesial and distal aspects were measured.

described a significant reduction in bone loss in all cases in which platform geometry was compared with the control group, for which matching-diameter implant platforms and abutments were used.[16] Some studies have shown that the bone remodeling can be biologically ascribed to the bacterial colonization of microleakage present in a two-stage implant system and subsequent inflammation.[19,20] The crestal bone loss that occurs around implants has both horizontal and vertical components. Following abutment connection, crestal bone has been shown to recede from the implant/abutment junction microgap by 1.3 to 1.4 mm, as measured horizontally.[21]

The mean bone resorption around implants is typically 1.72 mm approximately 6 months after implant placement.[8,21] Studies have also demonstrated the overall buccal resorption of hard and soft tissues after tooth extraction.[1,22,23] Canullo and Rasperini demonstrated that, in conjunction with postextractive immediate loading implant procedures, platform switching can preserve soft and hard tissues and therefore may provide better esthetic results, with mean bone resorption of 0.78 mm after 18 to 36 months of follow-up.[17]

Ericsson et al restored 14 Brånemark System implants immediately with single-crown restorations and compared them with eight implants that were loaded following the standard protocol. They reported survival rates of 86% in the immediate loading group and 100% in the standard loading restoration group. Both groups showed a marginal bone loss of 0.1 mm at 18 months.[24]

Glauser and coworkers studied 102 TiUnite implants that were placed in 38 patients and immediately loaded. The implants supported 20 single-tooth restorations, 30 fixed partial dentures, and one complete fixed mandibular restoration. The researchers reported a cumulative implant survival rate of 97.1% after 1 year of prosthetic loading, with a mean marginal bone resorption (± SD) after 1 year of loading of 1.2 ± 0.09 mm.[25]

The results of the studies reviewed here should be considered with caution, since great variability exists among them regarding inclusion and exclusion criteria for patient selection, area of implant placement (maxilla vs mandible), and loading protocols.

CONCLUSION

The present prospective study achieved a 96.7% survival rate at 12 months for platform-switched immediate implants restored immediately with nonsplinted restorations in the anterior and premolar regions of the maxilla. Radiographic observations suggest that the postoperative biologic process, which typically results in the loss of crestal bone height, is altered when the platform-switching technique is used. Crestal bone resorption was also minimal: 0.08 ± 0.53 mm on all implants mesially and 0.09 ± 0.69 mm distally on average. The levels of crestal bone loss in the present study appear slightly lower than the results described in the literature. Further clinical trials with larger sample sizes and longer follow-up periods are needed to demonstrate the long-term success of this procedure.

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