A Short-term Clinical Evaluation of Immediately Restored Maxillary TiOblast Single-Tooth Implants

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Purpose: *The purpose of this study was to evaluate the short-term clinical outcome of single-tooth implants placed in the maxilla and immediately restored using cementless friction-fit temporary crowns.* ***Materials and Methods:*** *Twenty-five patients consecutively referred to a private specialist practice for the replacement of failing or missing maxillary teeth were treated by means of immediate temporization of their single-tooth implants. Where teeth were still present, implants were placed immediately following extraction. Provisional crowns were fabricated on a special friction-fit coping by means of autopolymerizing acrylic resin. Definitive crowns were placed a mean of 4.5 months after surgery. Implant survival was recorded along with the level of the marginal bone relative to a fixed reference point 1 year after placement. Any adverse soft tissue changes were also noted.* ***Results:*** *A total of 28 Astra Tech ST dental implants were placed. The overall survival rate at the end of the study was 96.4% for implants which were in function for periods ranging from 15.7 to 27 months. One patient, a smoker, lost 1 implant within 1 month of surgery. Mean marginal bone loss was 0.40 mm (range 0 to 1.53 mm) 1 year after placement of the implants. Many implants (37.5%) had no observed bone loss. No implants or crowns have been lost during the functional loading period. One implant was associated with an unfavorable recession of soft tissues; however, most maintained an esthetic gingival architecture. Eleven of 28 provisional restorations needed treatment; 6 required replacement during the temporization period, and 5 required cementation because of looseness. The ease of removal of the crowns allowed regular access for irrigation with chlorhexidine and thus maintenance of soft tissue health.* ***Discussion:*** *The need to provide provisional restorations for single-tooth gaps often presents challenges. An immediate temporary partial denture or adhesive prosthesis may be unacceptable or impractical. The current study describes a simple method for the immediate temporization of single-tooth implants. The results did not indicate any negative influence on osseointegration or short-term survival once the implants were functionally loaded.* ***Conclusion:*** *Immediate temporization of maxillary single-tooth implants can be both safe and predictable, and it appears that the procedure can yield favorable soft tissue esthetics.* INT J ORAL MAXILLOFAC IMPLANTS 2004;19:274–281

Key words: *immediate placement, single-tooth implants, temporization*

The application of endosseous implants for the restoration of single missing teeth is widely accepted and has been reported in a number of studies[1–5] that suggest a predictable outcome. Some of these studies[2–5] have been published with long-term data, a basic criterion for demonstrating the success of an implant.

The option of implants for the replacement of teeth has been a valuable addition to established conventional methods; however, the time required for treatment, the need for additional surgical procedures, and particularly the need for indefinite periods of temporization are obstacles that occasionally result in patients deciding against implant-based treatment.

Based on the aforementioned concerns, treatment of the edentulous mandible was advanced by the introduction of 1-stage surgery with an immediate loading protocol. Studies using this protocol[6–8] were able to demonstrate success rates ranging from 85% to 100%. These studies emphasized the need for cross-arch splinting to provide protection against micromotion of the implants, which can result in early failure. However, in subsequent investigations

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Table 1 Individual Patient Data

Patient	Age	Sex	Tooth position*	Time between surgery and final restoration (mo)	Immediate/ healed	Time since surgery (mo)†	Mo in function	Bone loss (mm)	Complications
DF	58	M	7 (12)	3	I	30	27	0.00	Recession
VW	30	F	6 (13)	2	H‡	26	24	1.53	
SH	33	F	8 (11)	5	H‡	27	22	0.00	
KC	41	F	10 (22)	3	H	26	22	0.15	
TE	58	M	10 (22)	4	I	25	21	0.00	
HW	67	F	7 (12)	7	I	24	17	0.72	
JS1	61	F	12 (24) 13 (25)	4	H I	24	20	0.99	
NS	46	M	8 (11)	3	I	24	20	0.00	
MH	37	M	8 (11)	5	H	22	17	0.00	
CB	39	F	10 (22)	4	I	21	17	1.35	
JS2	51	F	8 (11)	3	H	20	17	0.89	
BC	42	M	8 (11)	6	H	19	13	0.62	
TB	62	M	8 (11) 9 (21)	7	H I	19	12	0.08	
OG	65	F	5 (14)	4	H	21	16	0.25	
CM	40	M	9 (21)	3	I	20	17	0.00§	
JH1	50	F	7 (12) 9 (21)	5	H I	18	14	0.70	
VM	72	F	9 (21)	3	I	17	14	0.00§	
BB	58	F	9 (21)	—	H	—	—	—	Failure
MD	33	M	8 (11)	4	I	16	12	0.50	
JH2	45	M	9 (21)	8	I	16	8	0.00	
SZ	41	F	8 (11)	7	H	18	9	0.78	
LC	36	F	9 (21)	5	I	14	9	0.00	
DH	27	M	8 (11)	5	I	14	9	0.15§	
EI	70	F	7 (12)	4	I	14	10	0.15	
AP	42	F	10 (22)	4	I	13	9	0.00	
Mean	48.2			4.5		20.3	15.7	0.40	

Total number of implants = 28 (16 immediate, 12 healed); total number of patients = 25 (10 men, 15 women).
*Universal tooth numbering system used with FDI system numbers in parentheses.
†Immediately loaded/healed site.
‡Congenitally absent.
§Excluded from the calculation of the mean data.

evaluating the outcome for individual unsplinted implants with respect to immediate restoration,[9–12] implant survival rates ranged from 80% to 100% with up to 5 years of follow-up. Interpretation of these studies, however, requires careful assessment of the reported results. Although a majority of these studies have included the words "immediate loading" or "immediately loaded" in their titles, the implants in these studies have not been subjected to direct functional loading, since all fixed provisional restorations were carefully relieved of both centric and excursive occlusal contacts. It is therefore misleading to describe these implants as being immediately loaded. A more accurate description would be "immediately restored" or "immediately temporized." Nonetheless, unsplinted implant-supported restorations are still potentially subject to micromotion, and in this respect, these studies are of considerable interest.

The current study was designed to take advantage of the standard components of the Astra Tech implant system (Astra Tech, Lexington, MA), in which friction-fit copings could provide retentive cores for provisional restorations. The implant system used for this study has been well documented using conventional protocols,[3,5] with reported survival rates up to 100%. The primary objective of this study was to investigate a quick and relatively inexpensive technique to allow for the fabrication of nonfunctional but esthetic provisional restorations for the immediate temporization of implants. The survival rate and marginal bone response were determined.

MATERIALS AND METHODS

Patients were recruited between June 2000 and November 2001. Individual patient data are shown in Table 1.

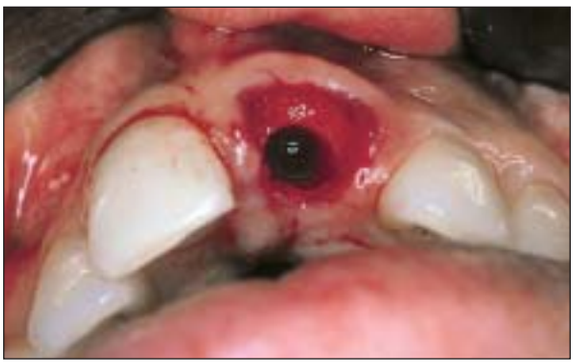

Fig 1 Surgery can be performed through the socket without raising a mucoperiosteal flap.

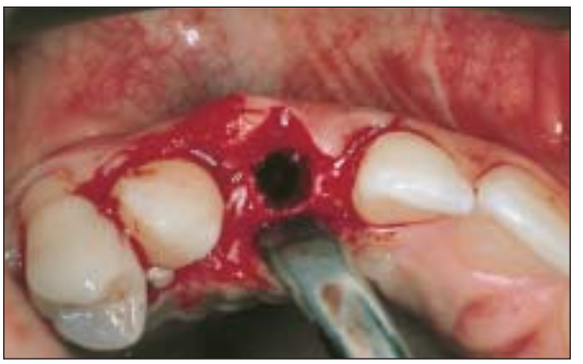

Fig 2 For healed sites, a palatocrestal-scalloped incision was used to recreate the gingival architecture.

The prospective inclusion criteria for the study were:

- Systemic health
- Absence of local purulent infection
- Teeth for extraction not be tender to percussion
- Adequate bone volume to receive an implant ≥ 4.5 × 11 mm
- ≥ 5 mm bone apical to the extraction socket
- Grafting limited to circumferential socket defects
- Primary fixation at 25 Ncm

Twenty-five patients were consecutively treated. All had acceptable systemic health. Patients diagnosed with diabetes were excluded, but smokers were included. Ten men and 15 women with a mean age of 48.2 years (range of 27 to 72 years) were referred for the replacement of missing teeth and/or extraction of failing teeth, typically the result of periodontal disease, endodontic failure, root fracture, or trauma. Sixteen teeth required extraction. The other 12 sites in the sample were completely healed. Ten were the sites of previous extractions (n = 10); 2 of the sites were congenitally absent of teeth (Table 1).

All patients, after being informed about the treatment protocol, signed an informed consent form. The experimental nature of the protocol was emphasized.

When requested by the patient, surgery was conducted under intravenous sedation; otherwise, all procedures were conducted under local anesthetic. Amoxicillin (or an equivalent for penicillin-allergic patients) was used as an antibiotic prophylaxis. Patients were given 3 g preoperatively and then 250 mg 3 times daily for 5 days postoperatively. All patients were asked to rinse with a 0.2% wt/vol chlorhexidine gluconate mouthwash (Corsodyl; GlaxoSmithKline, Maidenhead, United Kingdom) for 1 minute preoperatively and then twice a day for 1 minute for 1 week postoperatively.

Extractions were facilitated by means of a periotome and gentle elevation, and every effort was made to ensure maintenance of the labial cortical plate. All extraction sockets were thoroughly debrided with aggressive curettage prior to the immediate placement of implants. The implant osteotomy was performed through an apicopalatal aspect to avoid perforation of the labial/buccal plate. Limited flap elevation or flapless surgery (Fig 1) was employed whenever possible. However, if a labial/buccal concavity was noted clinically or there was a concern for breach of the integrity of the cortical plate, a mucoperiosteal flap was elevated to allow visual inspection during osteotomy preparation. Similar parameters were employed in healed sites, where a minimal flap design involved a palatocrestal scalloped incision with sulcular relief, allowing careful elevation of the intact papillae to expose the ridge crest and create a scalloped architecture on the labial aspect (Fig 2).

For healed sites, osteotomy preparation followed the manufacturer's protocol, as previously described.[1] For extraction sites, the conical drill was employed only when the socket diameter was less than the diameter of the head of the implant (diameter 4.5 mm, n = 18; diameter 5.0 mm, n = 10). In some patients, the palatal location of the implant required flaring of the palatal cortical plate only. The preparation was completed to ensure that the top of the implant could be located approximately 0.5 to 1.0 mm below the crestal bone, approximately 4.0 mm below the free gingival margin.

Implants were self-tapping. The osteotomy was prepared with a diameter 0.3 mm less than the diameter of the apical portion of the implant so that the implant compressed the bone slightly. A torque driver set at 25 Ncm was used to evaluate primary stability

Fig 3a The prefabricated Astra Tech ST abutment in situ, with visible retention grooves and anti-rotational octagon.

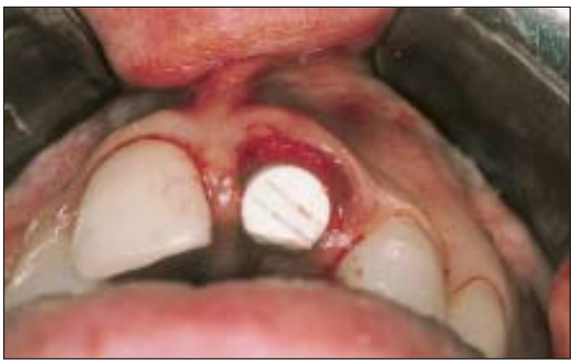

Fig 3b The friction-fit plastic impression coping was used as a core for the temporary crown. The retention tags have been cut off.

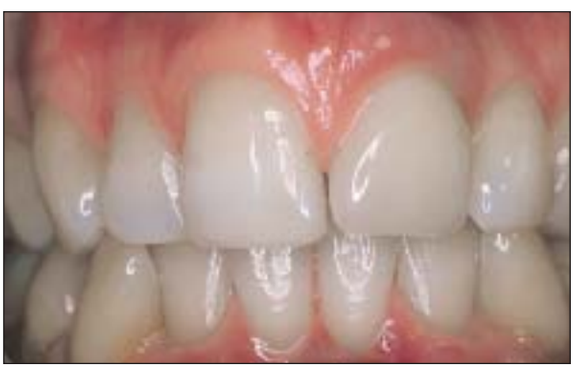

Fig 3c This clinical photograph was taken 1 week postoperatively and demonstrates the temporary crown in the maxillary left central incisor position made from a denture tooth bonded to the core with autopolymerizing acrylic resin.

Fig 3d The definitive restoration at the 1-year review.

of the implant. This torque was based upon a small test series of 3 implants using the resonance frequency analysis instrument (Ostell; Integration Diagnostics, Göteborg, Sweden), which indicated that when inserted with a torque of 25 Ncm, the implant stability quotient (ISQ) value of these implants was equivalent to that expected for an osseointegrated implant (ISQ ≥ 60). It was also the level of torque that the manufacturer recommended be applied to the abutment screw when seating the prefabricated single-tooth abutment (Astra Tech) (Fig 3a). To detect and prevent unfavorable rotation of the implant, the abutment was secured through a mounting sleeve that allowed manual detection of rotation. Any implants found to have rotational stability less than 25 Ncm were excluded from the study.

After abutment connection, a prefabricated friction-fit plastic coping was reduced and shaped to create a core, which was placed over the abutment, engaging the octagon for mechanical retention (Fig 3b). A provisional autopolymerized acrylic resin crown could then be fabricated over the coping. Initially, this procedure involved the use of shell-

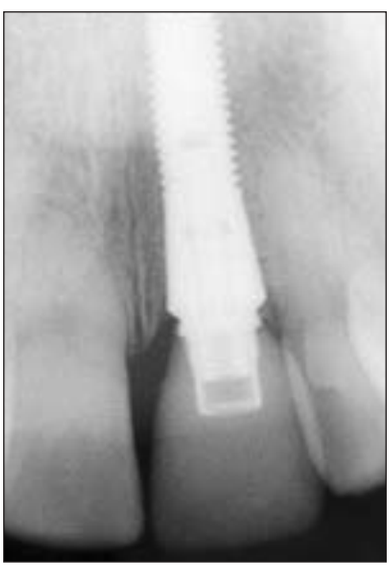

Fig 3e One-year review radiograph of implant. Note the bone level at the top of the implant, which is close to the microgap on the distal aspect.

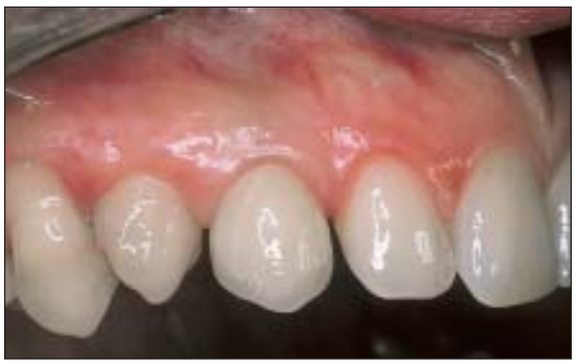

Fig 4 The definitive all-ceramic Procera crown at the site of the maxillary right canine in patient VW at the 1-year review.

formers filled with Trim acrylic resin (Harry J. Bosworth, Skokie, IL). However, due to degradation of the esthetic appearance of these crowns over a period of 4 months, this technique was discontinued in favor of using carefully matched denture teeth, hollow ground to create veneers, which were then bonded to the coping with the Trim acrylic resin (Fig 3c). The denture veneer maintained a long-lasting luster and resisted staining. Staining had been a problem with the autopolymerized provisional restorations.

The provisional crowns were carefully contoured and polished to achieve proper emergence profile and adaptation to the gingival tissues, to ensure congruence with the scalloped gingival architecture, and to provide the appropriate support to the interdental papillae. Furthermore, the occlusion was adjusted to relieve all centric and excursive contacts, thus avoiding any direct functional loading. Patients were advised of the vulnerability of the implants during the first 2 months postplacement and were strongly advised to refrain from applying loading force to them.

Sutures were avoided whenever possible, but when indicated a 6/0 Prolene monofilament was employed (Ethicon W8005; Ethicon, Johnson & Johnson, Somerville, NJ).

Patients were examined 1 week postoperatively to remove sutures and to assess the stability of both the provisional crowns and the implants. Subsequently, all patients were seen 1 month postoperatively and monthly thereafter for removal of the friction-fit crown to allow direct assessment of implant stability and to provide the opportunity to irrigate the submucosal peri-implant sulcus with 0.2% wt/vol chlorhexidine solution. In addition, a 1% chlorhexidine gel (Corsodyl; GlaxoSmithKline) was applied to the inside of the crowns, which were then reseated. This gel can leach out over time, helping to enhance the health of the peri-implant tissues.

All patients were either referred back to their dental practitioner for restoration or restored by the author approximately 4.5 months after surgery with either a metal-ceramic or an all-ceramic crown (Procera; Nobel Biocare, Göteborg, Sweden) (Figs 3 and 4).

Standardized intraoral radiographs were taken using a Rinn device (Dentsply-Rinn, Elgin, IL) prior to the cementing of the definitive restoration and again at the annual recall. Only the most recent radiograph was used to record the change in bone levels, which was measured under 8× magnification from the reference point at the top of the implant, which coincides with the microgap at the implant-to-abutment junction. Measurements to the bone crest at the mesial and distal points of the implant were facilitated by the knowledge that this reference point is 0.7 mm from the first Microthread and that the pitch of the Microthread is 0.185 mm. The mesial and distal bone loss figures were averaged for each implant, and the mean for the total group data was calculated.

RESULTS

The time to complete the same-day procedures, including extractions where indicated, implant placement, and temporary crown fabrication ranged from 60 to 90 minutes.

Implant lengths ranged from 11 to 17 mm, with the majority (79%) being 13 or 15 mm in length. The abutment length selected was the shortest available (Astra notation = 0.0 mm) in all but one case (patient AP received a 1.0-mm abutment), yielding a crown margin 1.0 mm above the top of the implant.

For the 25 patients in the study, abutments were tightened to 25 Ncm, and all received an esthetically acceptable provisional restoration fabricated on the same day. For an additional 8 patients, it was not possible to achieve rotational stability at 25 Ncm, and these patients and their implants were excluded from the study.

One patient presented at the 1-month review complaining of mobility. She habitually protruded her mandible and thus had difficulty avoiding loading the provisional crown. The implant was assessed as being both rotationally and axially unstable and was subsequently removed. This implant was successfully replaced and restored using a 2-stage submerged protocol.

Twelve all-ceramic and 16 metal-ceramic definitive crowns were placed a mean of 4.5 months after surgery (range from 2 to 8 months), with any delayed placement resulting from the appointment schedule of the referring dental practitioner or patients' scheduling conflicts.

Definitive crowns have been in function for a mean of 15.7 months (range 8 to 27 months); implants have been in situ for a mean of 20.3 months (range 13 to 30 months). No further implant failures were detected during the study period, yielding a survival rate of 96.4%.

Two patients permanently relocated and were lost to follow-up. However, both patients received their definitive crowns. A radiograph taken at the time of crown insertion showed no evidence of marginal bone loss. These 2 implants, along with the 1 implant failure and 1 implant in a patient unable to attend her 1-year review because of illness, have been excluded from the mean marginal bone loss data. For the remaining 24 implants in 21 patients, radiographs taken at least 1 year after surgery were available for assessment (Fig 3e). The mean marginal bone loss from the time of implant placement, as measured from the reference point at the top of the implant, was 0.40 mm (range 0 to 1.53 mm). Bone loss occurred with 62.5% of the implants. Bone was recorded at or even above the implant-abutment junction in more than one third of the implants. Any positive bone levels with respect to the reference level were recorded as zero bone loss so as to not positively influence the data.

The only other adverse event to be recorded during the study was an undesirable recession of the soft tissues and gingival margin from around 1 implant and the juxtaposing teeth in 1 patient. This was attributed to the deep placement of the implant and an unfavorable labial inclination of the implant/crown complex, which may have resulted in an unacceptable amount of pressure on the labial soft tissues. Although the esthetic result was poor, both the marginal bone levels and the implant stability remained unchanged.

DISCUSSION

With increasing awareness of dental implants, more patients are demanding treatment with implant-supported restorations over conventional alternatives. The only significant obstacles perceived by the patients to this treatment have been the long treatment times, the need for multiple surgical procedures and in some cases, the inconvenience of an undesirable temporary restoration and cost.

The relatively recent introduction of an immediate loading protocol has removed many of these obstacles, since the typical delay to placement of an implant-supported restoration is effectively eliminated, only 1 surgical procedure is required, and the patient benefits from not having to wear a removable or bonded provisional restoration. Many of the early studies on immediate loading were based upon restoration of the edentulous mandible, where bone density is known to be favorable and cross-arch splinting is possible to minimize micromovement, which can be a principal cause of early implant failure.[6–8]

The desire to overcome these obstacles has also led to further studies investigating the outcome for immediately loaded implants in the maxilla for both splinted and unsplinted implants.[13] Other studies have also reported specifically on the survival of single-tooth implants with provisional restorations placed on the day of surgery.[9–12] These implants, the majority of which were placed in the maxilla, were not splinted and were therefore potentially subject to micromovement and overload. Although many of these articles misleadingly imply in their titles that the implants were immediately loaded, close scrutiny of the methodology reveals that in most cases the provisional restorations were kept clear of functional contacts.

This current report supports the small group of studies confirming that it is possible to obtain short-term implant survival equivalent to that reported using 2-stage conventional protocols (96.4%).

The marginal bone change at 24 implants was evaluated from radiographs taken a minimum of 1 year (range 13 to 30 months) after implant placement, and a mean of 15.7 months after insertion of the definitive crowns (range 8 to 27 months). The bone level was measured relative to the location of the reference point at the top of the implant, which was always placed at or just below the crest of the ridge. Bone loss was measured this way because implants were not subject to a second surgical procedure. Any initial changes in bone levels were not the result of further surgical trauma such as occurs between the time of exposure and definitive crown placement, but were the result of the physiologic response to the immediate restoration of the implants and any microbial influence through the peri-implant sulcus or microgap.

The change represents the total change in bone height over the short-term healing period and is therefore a more exacting evaluation of the marginal bone response around this implant, which the manufacturer claims has specific bone-maintaining features, ie, the TiOblast surface and the Microthread,

which are applied to the entire length of the implant.[14] Certainly the high frequency of implants with no recorded marginal bone loss (37.5%) and the low mean marginal bone loss (0.40 mm) would seem to support this claim, especially when all positive bone levels with respect to the reference level were recorded as zero. These findings contribute to the controversy surrounding the current theory that bone cannot be maintained closer than 1 to 2 mm from the microgap,[15] since the reference point for Astra Tech implants is at the level of the microgap.

The empirical use of torque to determine the suitability of an implant for a same-day restoration technique, from the perspective of immediate primary stability, was based upon a small test series of 3 implants using a resonance frequency analysis instrument (Ostell, Integration Diagnostics). In this test it was noted that when an implant was resistant to rotation at 25 Ncm, the ISQ was ≥ 60, which is close to that reported for an osseointegrated implant.[16]

The ability to fabricate a simple yet esthetically effective provisional crown was appreciated by all the patients, since no impressions were required, no laboratory time or cost was incurred, and in all but 1 patient, an esthetic outcome was obtained. It was apparent that the contour of the provisional crown could be used to maintain the gingival architecture and ensure appropriate support of the free gingival margin and the interdental papillae. The use of autopolymerizing resin intraorally did not appear to cause any adverse reactions by the soft tissues.

The use of a friction-fit coping proved invaluable, since this eliminated the need for cementation and allowed the regular removal of the crown for submucosal irrigation with chlorhexidine and ongoing assessment of the supporting implant. In addition, the adjunctive application of a chlorhexidine gel inside the temporary crown proved beneficial for the maintenance of tissue health between visits. However, it was noted that 6 crowns required replacement because the plastic coping split over time, and another 5 crowns were eventually cemented in place as the result of persistent looseness. At no time did any crown become so loose that aspiration was a risk; however, this 39% complication rate is cause for some concern. A small amount of temporary cement used at insertion of the provisional crown could have reduced this figure.

The implants in the current study were definitively restored a mean of 4.5 months after surgery, 12 with all-ceramic Procera crowns (Nobel Biocare). No complications have occurred with any of the definitive crowns.

CONCLUSION

In this patient population, using this treatment approach, the Astra Tech ST implant system was reliable and predictable for immediate implant placement and restoration with provisional acrylic resin crowns in the short term. The use of a friction-fit acrylic resin provisional crown fabricated chairside allowed for close adaptation to the gingival architecture and optimal tissue health, related in part to the ability to regularly remove the crown for submucosal irrigation with chlorhexidine.

The close relationship between the marginal bone level and the so-called microgap warrants further investigation and consideration. The application of a rough surface and retention elements to the top of this implant contrasts with the designs of other implants, which have a smooth, machined collar. In combination with the Astra internal conical connection, this may explain the maintenance of crestal bone.

With a survival rate of 96.4% and a mean marginal bone loss of 0.40 mm after a mean of 15.7 months in function, the clinical survival rate is comparable to short-term results achieved using the more conventional 2-stage implant protocol.

ACKNOWLEDGMENTS

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