A Retrospective Analysis of Peri-Implant Tissue Responses at Immediate Load/Provisionalized Microthreaded Implants

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Purpose: *The aim of this retrospective study was to examine the peri-implant tissue status at immediately provisionalized anterior maxillary implants 12 to 30 months following tooth replacement.* ***Materials and Methods:*** *This is a retrospective study of 43 microthreaded, TiO_2 grit–blasted implants placed in healed ridges and immediate extraction sockets to restore maxillary anterior and premolar teeth in 28 patients. The cortical bone position relative to the implant reference point was evaluated at implant placement and 6 to 30 months following restoration. Radiographs were assessed using 7× magnification. The distance from the reference point to the cortical bone was measured to ± 0.1 mm. The relationship of the peri-implant mucosa to the incisal edge of the definitive prosthesis was recorded.* ***Results:*** *Four implants in 3 individuals failed during the first 6 weeks following placement and provisional loading. Cortical bone adaptation from the time of implant placement up to 30 months following restoration ranged from 0.0 mm to 1.5 mm (average, 0.33 ± 0.40 mm mesially and 0.28 ± 0.37 mm distally). The mean radiographic measurements from the interproximal crestal bone to the contact point were 4.53 ± -0.91 mm (mesial) and 4.06 ± 0.98. Maintenance and growth of papilla was observed in this group of immediate provisionalized single-tooth implants. Definitive abutment or abutment screw loosening was not observed.* ***Discussion:*** *The linear clinical and radiographic measures of peri-implant tissue responses suggest that proper implant placement is followed by supracrestal biological width formation along the abutment and preservation of toothlike tissue contours. This may influence buccal peri-implant tissue dimensions.* ***Conclusions:*** *Generalized maintenance of crestal bone and the increased soft tissue dimension with maintenance of peri-implant papilla were identified as expected outcomes for immediate loading/provisionalization of microthreaded, TiO_2 grit–blasted implants. Control of peri-implant tissues can be achieved to provide predictable and esthetic treatment for anterior tooth replacement using dental implants.* (Case Series) INT J ORAL MAXILLOFAC IMPLANTS 2006;21:405–412

Key words: *biological width, dental implants, immediate loading, marginal bone level*

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The immediate replacement of single teeth by provisional restoration of dental implants is a procedure of growing interest among clinicians worldwide. While short-term data exist concerning the initial success of implants placed and provisionalized at the time of tooth extraction, there is little information regarding the tissue responses following this particular implant therapy. Beyond implant survival, the peri-implant mucosal responses are critical determinants of single-tooth replacement esthetics.

The extraction of a tooth root can result in marked changes in alveolar bone architecture.[1] Ridge preservation procedures and avoidance of osseous exposure by periosteal flap reflection are suggested approaches to limit deleterious resorption that precludes the ideal positioning of subsequently placed implants.[2] Immediate placement of implants has been further suggested to aid in preservation of the residual alveolar bone architecture.[3]

Implant and abutment placement is associated with bone adaptation responses in the transcortical or crestal region of the alveolus-implant interface.[4,5] The level of crestal bone is regarded as a central determinant of peri-implant mucosal architecture. Control of these peri-implant tissues is essential to esthetic outcome for endosseous dental implant restoration. Case reports have suggested that the immediate placement and provisionalization of endosseous implants and abutments offers additional clinical control over the peri-implant tissue architecture.[6]

Investigations from case-control studies have repeatedly suggested that peri-implant bone loss following conus implant-abutment connection at microthreaded and titanium oxide (TiO_2) grit-blasted implants is limited after conventional 2-stage, 1-stage, and early loading procedures.[7–9] Crestal bone levels that approximate the implant-abutment interface and marginal bone changes of approximately 0.5 mm have been reported. In a 3-year evaluation of early loading procedures, lack of crestal bone changes was associated with immediate and lasting positive changes in peri-implant mucosal architecture.[7]

More recent efforts have focused on examining the feasibility of tooth replacement using immediate provisionalization of implants placed into extraction sockets.[9,10] A complete risk-benefit analysis for single-tooth replacement should include the evaluation of peri-implant tissue responses following these procedures. Consideration of immediate implant placement and provisional restoration suggests that potentially deleterious osseous and mucosal responses could result from *(1)* the diverse anatomy and dimensions of extraction sockets, *(2)* the imposed loading environment of the provisional restoration, *(3)* the nature of the provisional restoration-mucosa interface, and *(4)* potential contamination of the healing site by restorative materials and dental cements. Single-tooth replacement in the anterior maxilla is favored by the dimension of extraction sockets, the reduced masticatory loads, and the obvious esthetic benefit relative to posterior tooth replacement. It is possible that the benefits of controlled peri-implant mucosal healing is another key benefit of immediate implant placement and provisionalization procedures. The aim of this retrospective study was to examine the peri-implant tissue status at immediately provisionalized anterior maxillary implants 12 to 30 months following tooth replacement.

MATERIALS AND METHODS

Twenty-eight subjects were treated for single-tooth replacement under an institutional review board–approved protocol. All patients required tooth extraction and replacement by immediate loading and provisional crown placement. Patients referred for implant placement were treated, irrespective of existing periapical infection, smoking status, or general dental health. Patients 18 years or older with avulsed, fractured, or otherwise nonrestorable maxillary teeth (including molars) were referred for treatment. All patients willing to provide informed consent and able to undergo tooth extraction and implant placement were treated.

Forty-three maxillary anterior or premolar teeth were extracted atraumatically with preservation of the buccal plate of bone. Buccal flaps were avoided in all but 1 patient. Implants (Astra Tech, Waltham, MA) were placed in prepared osteotomies (3.2 mm diameter for 3.5- or 4.5-mm ST implants; 3.7 mm diameter for 4.0- or 5.0-mm ST implants), and primary stability was assessed by uncomplicated reversal of the implant mount. Immediately following extraction, definitive abutments were selected (Direct abutments; Astra Tech) and/or prepared (Bi-Abutments; Astra Tech) and placed using finger tight pressure only. Provisional crowns were fabricated using bisphenol-A-glycidyldimethacrylate (BIS/GMA) resin (ProTemp; ESPE/3M, St Paul, MN) and were cemented using permanent cement (Ketac Cem, ESPE/3M). Cement removal was carefully performed using scalers and floss. The absence of opposing tooth contacts in maximum intercuspal position and excursive contacts was demonstrated using polyester film and articulating paper. Patients were evaluated at 7 to 10 days, 21 to 28 days, and 3 months postplacement. Definitive restorations were fabricated using all-ceramic crowns (Vita InCeram; Vident, Brea, CA, or Procera; Nobel Biocare USA, Yorba Linda, CA) and cemented with Ketac Cem.

Twenty-eight subjects consecutively treated by this immediate loading protocol were evaluated. In 3 individuals, 4 implants demonstrated mobility during the first 6 weeks. Although subsequently retreated, these implants were considered failures. The records of the remaining 25 patients and their 39 successful immediately placed and provisionalized implants were retrospectively considered. The cortical bone position relative to the implant reference point was evaluated by measuring existing radiographs using 7× magnification. Abutment complications were recorded. In 20 patients, 25 implants were clinically examined, and peri-implant mucosa was evaluated. Multiple attempts to recall all remaining patients

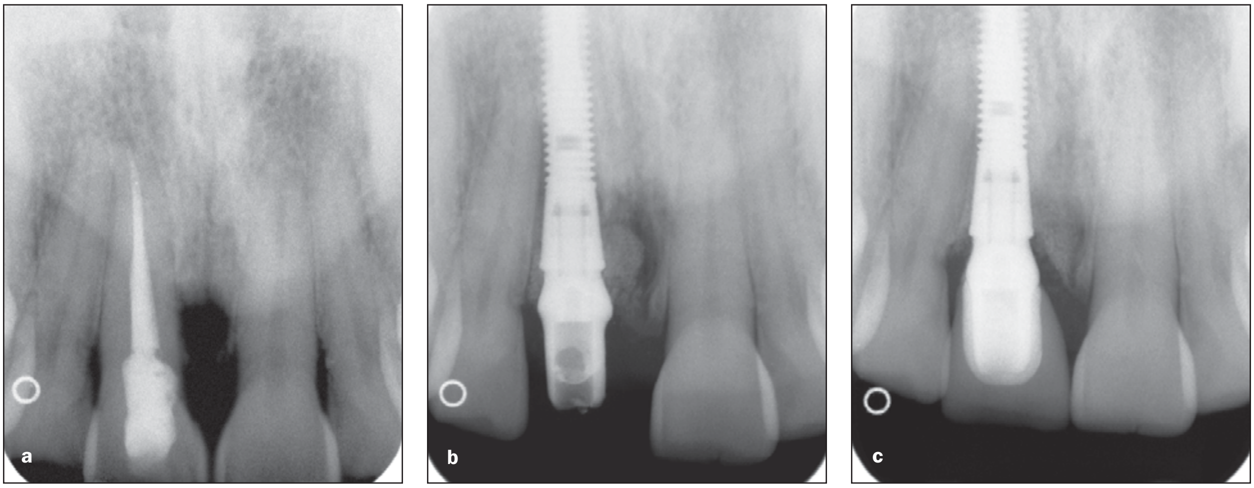


Fig 1 Radiographic assessment of implant-bone interface following immediate placement and provisionalization. *(a)* Preoperative radiograph of maxillary central incisor. *(b)* Radiograph immediately following tooth extraction, implant placement, and abutment connection. *(c)* Postoperative radiograph showing lack of bone loss 15 months after restoration.

were unsuccessful. For all 39 implants, radiographs taken at the time of implant placement were available for comparison to radiographs taken 6 to 30 months following implant placement. A single examiner measured digital radiographs acquired using a positioning device and the Gendex system (Danaher/Gendex, Washington, DC). Peri-implant sulcus depth was measured at 6 points circumferentially by a single examiner using a periodontal probe, and the potential for bleeding on probing was assessed.

Table 1 Average Probing Depths

	Mean (mm)	SD
Mesiofacial	3.10	0.64
Facial	2.35	0.81
Distofacial	3.20	0.30
Mesiolingual	2.95	0.68
Lingual	2.55	0.82
Distolingual	3.15	0.58

RESULTS

In the treatment process, 3 of 28 patients experienced failure of 4 immediately loaded implants within the first 6 weeks. In 1 patient, 2 implants placed at the sites of the central incisors failed after immediate placement into extraction sockets 3 weeks after blunt trauma and horizontal root fracture. In another patient, an implant placed in the maxillary right canine extraction socket failed; this failure was associated with purulent exudate and erosion of the buccal plate of bone. The other failed implant was observed 12 weeks following placement in the left maxillary central incisor extraction socket without discomfort, radiographic evidence of bone loss, or significant mobility. Failure was associated with implant mobility without pain or infection. There was no peri-implant mucosal inflammation at the time failure was reported. The remaining 39 implants included 12 central incisor, 9 lateral incisor, 5 canine, and 13 premolar replacements.

For 25 implants in 20 patients, peri-implant sulcus depth measurements were obtained at a recall visit 6 to 30 months following implant placement. Mean probing depths were approximately 3.0 mm and 2.5 mm at interproximal and midcoronal locations, respectively (Table 1). There was a generalized absence of bleeding on probing. No differences were found with respect to abutment type (Direct abutment versus Profile Bi-abutment) or site.

Peri-implant bone responses were evaluated by measurement of the mesial and distal marginal bone levels relative to a designated reference point that approximated the implant-abutment interface (Fig 1). On average, the distance between the reference point and the marginal bone level was 0.33 mm ± 0.40 mm mesially and 0.28 ± 0.37 mm distally. Of all sites measured radiographically, only 7.6% of the sites demonstrated marginal bone level reductions greater than 1.0 mm. The distribution of bone levels among the cohort is displayed in Table 2. Maintenance of papilla and buccal gingival contour was also observed. For the 20 individuals available for a recall clinical examination, an objective Papilla Index[3] (Table 3) was used to score the papillae. All implant restorations but one were associated with papilla regeneration and scores of 1 or 2.

Table 2 Distribution of Marginal Bone Reductions*			
	0.0–0.5 mm	0.6–1.0 mm	> 1.0 mm
No. of mesial sites	32	4	3
No. of distal sites	33	3	3

*Marginal bone reduction was determined by measuring the distance between the marginal bone level and a reference point. The reference point was the junction of the conical level and the TiO_2 grit–blasted surface (Fig 1).

Table 3 Papilla Index Scores		
	No. of sites preoperatively	No. of sites postoperatively
Class I	17	16
Class II	7	8
Class III	1	1
Class IV	0	0

Table 4 Radiographic Measurements of Implants Mesially and Distally

	Reference distance		IPB/CP	
Patient no.	Mesial	Distal	Mesial	Distal
1	0.1	0.5	3.7	3.8
2	0	0.1	7.0	7.1
3	0.3	0.2	5.2	5.1
4	0.8	0.6	3.6	3.4
5	0.2	0.3		3.8
6	0.0	0.1	4.4	4.3
	0.2	0.3	5.0	3.4
7	0.4	0.5	3.3	3.2
	0.0	0.0	4.3	*
	0.3	0.6	4.5	*
	0.4	0.4	3.7	3.5
8	1.5	0.2	4.8	3.4
9	0.0	0.1	3.5	3.6
	0.0	0.2	4.1	3.5
10	0.1	0.3	3.8	3.4
11	0.2	0.6	5.1	4.7
12	0.2	0.0	3.7	3.2
	0.1	0.4	3.7	2.9
13	1.0	0.0	4.4	3.3
14	0.5	0.1	5.1	3.8
	0.0	0.2	4.3	3.5
	0.0	0.2	4.6	3.4
	0.2	0.0	3.8	4.1
15	0.5	0.5	4.5	3.8
16	0.0	0.0	4.0	3.3
17	0.4	0.0	4.7	5.1
	0.0	0.0	5.5	4.5
	1.3	1.3	4.5	4.0
18	0.0	0.0	3.9	3.5
19	0.0	0.0	6.5	3.1
20	0.0	0.2	5.2	4.7
21	0.0	0.0	4.0	5.9
22	1.2	1.5	5.3	3.2
23	0.5	1.2	6.2	*
	0.7	0.0	5.6	6.8
	0.0	0.0	5.1	4.2
24	0.3	0.0	2.8	4.1
	0.8	0.0	3.5	4.8
25	0.5	0.2	5.3	4.7
Mean	0.33	0.28	4.53	4.06
SD	0.40	0.37	0.91	0.98

Reference distance = distance from the top of the implant to bone level mesial/distal to the implant.
IPB/CP = distance from the interproximal crestal bone (IPB) to the implant crown contact points (CP) mesial/distal to the implant.
*Sites could not be measured radiographically.

Radiographic measurements of the distance from the interproximal crestal bone to the implant-crown contact points were recorded at all 39 mesial locations and 36 distal locations after 6 to 20 months (Table 4). The average distance for mesial sites was 4.53 ± 0.91 mm and this was statistically different ($P < .016$) from the average measurement obtained for distal sites, 4.06 ± 0.98 mm.

DISCUSSION

Advocating immediate loading and provisionalization as a tooth replacement strategy requires data supporting the short- and long-term demonstration of osseointegration success. It further requires an understanding of the soft tissue integration of the peri-implant mucosa with the implant-abutment-crown complex. Such an understanding is particularly significant in light of the key role this procedure could play in immediate replacement of avulsed, fractured, or nonrestorable anterior maxillary teeth. The introduction of a provisional crown and an abutment through the mucosa at the time of implant placement diverges, and the subsequent biologic reaction, differ significantly from traditional 2-stage and relatively common 1-stage implant procedures. The present investigation sought to define the short-term results of the immediate provisionalization procedure for implants placed into extraction sockets using clinical and radiographic measures of peri-implant tissue relationships 12 to 30 months following restoration.

Two observations emerged from these measurements, and both support the contention that a consistent peri-implant tissue response can be defined for the procedure and components presently investigated. First, peri-implant marginal bone levels adapt to and are maintained at the implant reference point, approximating the implant-abutment interface (Fig 1). In this retrospective analysis, an immediate placement and loading protocol resulted in marginal bone levels that are similar to the marginal bone levels reported for similar microthreaded, titanium dioxide grit–blasted dental implants restored following 2-stage, 1-stage, or early loading protocols (Table 5). The present findings also replicate the recent 1-year

Table 5 Measured Marginal Bone Levels for Microthreaded, Titanium Dioxide Grit–Blasted Implants

Study	Year	Application	Marginal bone level (mm)
Karlsson et al[11]	1997	2-stage	−0.31
Kemppainen et al[12]	1997	2-stage	−0.14
Norton et al[13]	1998	2-stage	−0.32
Cooper et al[14]	1999	Immediate prov	0.23
Astrand et al[15]	1999	2-stage	−0.03
Cooper et al[7]	2001	Early load	−0.41
Palmer et al[8]	2003	Conventional	−0.50
Gotfredsen[16]	2004	1-stage	< −0.50
Norton[9]	2004	Immediate load	−0.44

prov = provisional.

observations for immediate loading of Astra Tech implants reported by Norton.[9]

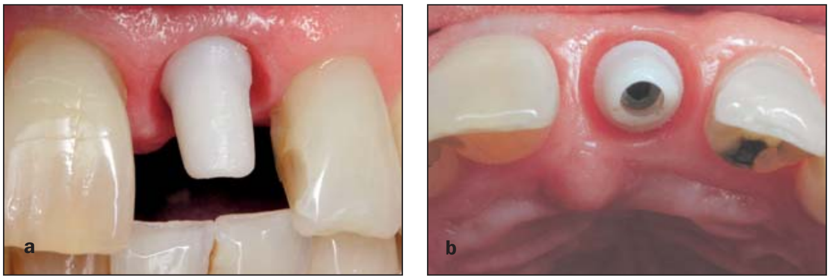
The present results may be specific for the particular system investigated. However, at least 1 prospective analysis indicated no difference between Astra Tech and Nobel Biocare implants with respect to crestal bone response at the implant-abutment interface.[15] This lack of difference may be the result of potential variation in depth of placement or differences in the measurement of bone levels superior to the implant-abutment interface. This study did not evaluate implants of a microthread design, which have been implicated in bone maintenance.[17] Another comparative investigation[18] had results similar to those described here (ie, relatively little bone loss). Irrespective of comparisons among systems, the current data offers an important data set to guide clinical application of the system presently investigated.

Secondly, this retrospective analysis revealed a consistent peri-implant sulcus depth of 2.35 to 3.15 mm circumferentially around the endosseous dental implant. One interpretation of this clinical parameter is that implant placement was relatively shallow and this is, in fact, an important consideration during immediate placement. It is presently advocated that the depth of implant placement be no less than 2 mm and no greater than 3 mm apical to the adjacent clinical crown margin or the facial gingival zenith. Further, it is recommended that the implant-abutment interface should not be placed beyond the facial osseous crest. Shallow implant placement requires careful subsequent abutment selection and clinical crown margin location (Fig 2).

It is well known that a biologic width is formed at dental implants. Gargiulo and associates[19] first described the biologic width at natural teeth and concluded that the average sulcular depth is 0.69 mm; the average junctional epithelium, 0.97 mm; and the supra-alveolar average connective tissue attachment, 1.07 mm. When all the dimensions are combined, the average biologic width is about 2.04 mm.[19] The peri-implant mucosa typically includes a junctional epithelial contact of 1.0 to 1.5 mm and a connective tissue contact of approximately 1.0 mm.[20,21] Cochran and colleagues[21] demonstrated that tissues around nonsubmerged dental implants are dimensionally and physiologically stable structures and that they have a natural relationship to one another. These soft tissues provide structural support similar to gingiva and also provide a protective barrier for the underlying bone.[22]

Replicating the anatomic details of the pericoronal tissues by determined development of peri-implant tissues around single-tooth implants may be possible when crestal bone is preserved. A third observation highlights the important biologic limitations affecting clinical attempts to completely develop peri-implant mucosal architecture at implant crowns. Specifically, the distance from the crestal bone to the clinical crown contact point was an average of 4.53 ± 0.91 mm mesially and 4.05 ± 0.98 mm distally. Previous investigators have noted similar dimensions for natural teeth.[10] The evaluation of immediate provisionalization suggests that the presence of adjacent teeth does influence this dimension[10] and underscores the importance of this value as a dimensional limit for interproximal tissue development. The development and maintenance of much more than 4.5 to 5.0 mm of tissue superior to crestal bone is not supported by the present study of immediate provisionalization and is congruent with previous reports of peri-implant tissue responses at dental implants.[5] This finding additionally highlights the clinical value of maintenance of crestal bone volume to support the limited peri-implant mucosal development that is possible superior to the bone crest (Fig 3). Planning for esthetically pleasing outcomes requires acknowledgment of this dimensional constraint and an understanding of crestal bone levels at the implant placed.

Contrasting the present interpretation that complete architectural replication can be achieved by directed peri-implant tissue management, Chang and coworkers[23] indicated that soft tissue dimensions of intact natural teeth differed from those around single implant-supported restorations. In a clinical comparison of implant and natural tooth crowns, it was reported that that the crown placed onto an implant after a 6-month healing period was longer and thinner faciolingually, with a thicker facial mucosa. The distal papilla beside the implant had lower height, and implants were associated with more mucositis, more bleeding on probing, and deeper probing depths.



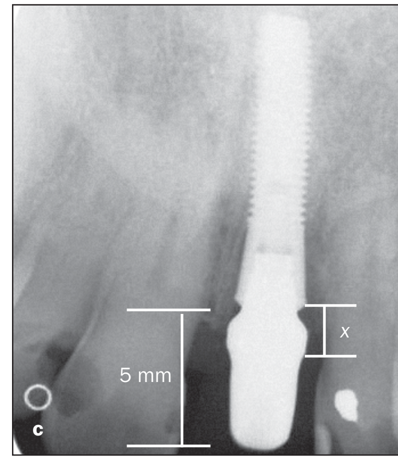


Fig 2 Abutment-tissue relationships 10 weeks following implant and abutment placement into extraction socket. *(a)* Implant and abutment placement permitted proper emergence from peri-implant mucosa and controlled the peri-implant mucosal zenith. *(b)* Occlusal view of ceramic abutment-tissue relationship reveals healthy epithelialization of the peri-implant sulcus. *(c)* Twelve-month postoperative radiograph reveals the marginal bone level approximating the implant-abutment interface. The distance from the implant-abutment interface to the clinical crown margin is indicated interproximally *(x)* while the distance from the implant-abutment interface to the contact point is 5 mm.

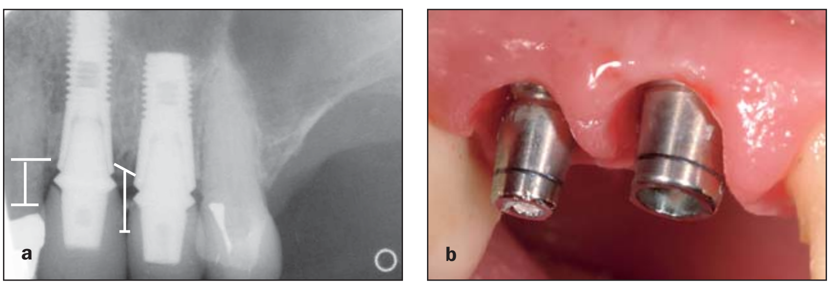


Fig 3 Supracrestal soft tissue formation and maintenance was achieved after immediate placement and provisionalization. *(a)* Periapical radiographic evaluation of the interimplant-bone relationship with the implant-abutment interface suggests maintenance of bone between adjacent implants. *(b)* Clinical lateral photograph of interimplant mucosa indicates the preservation of tissue and established papilla between 2 implants.

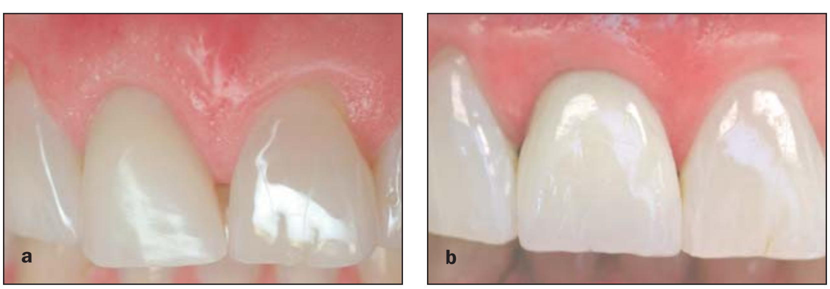


Fig 4 Soft tissue healing following immediate placement and provisionalization. *(a)* The maintenance of peri-implant tissues after implant placement was indicated by the coral pink, stippled attached gingival and knife-edged morphology of the free gingival margin at the provisional restoration placed on the maxillary right central incisor. *(b)* The maintenance of the structure and texture of the peri-implant tissues at the 15-month follow-up examination of the definitive crown.

More recently, Kan and associates[10] examined the results of immediate tooth replacement and indicated that an advantage of this approach over staged therapy was the esthetic peri-implant tissue that resulted. Further direct clinical comparison of natural tooth-supported and immediate implant-supported crown restorations is warranted.

The integration of soft tissue with the abutment-crown complex is an important yet poorly studied phenomenon as related to the immediate provisionalization process (Fig 4). Analysis of the tissue dimensions strongly suggests that the biologic width was reproducibly formed, in large part, against the abutment surfaces in a position superior to crestal bone. For example, the measured dimension of soft tissue and location of the marginal bone level at the implant-abutment complex indicates that the connective tissue contact develops along the machined titanium bevel, the implant abutment interface, and the abutment per se. The junctional epithelium may adhere to the abutment, and the sulcus forms against the abutment and or crown. This proposed structure is supported by histologic evaluation of peri-implant mucosa formed at titanium and aluminous ceramic abutments following 2-stage healing in a beagle dog model[24] and is consistent with the peri-implant mucosa described following 1-stage healing in a similar model.[21] The treatment planning and clinical execution of single-tooth replacement using immediate provisionalization of a dental implant should focus on the establishment and maintenance of the biologic width against the abutment. When crestal bone responses are controlled, this is possible in a reproducibly controlled manner.

The peri-implant tissue topography and soft tissue position are keys to obtaining optimal dental

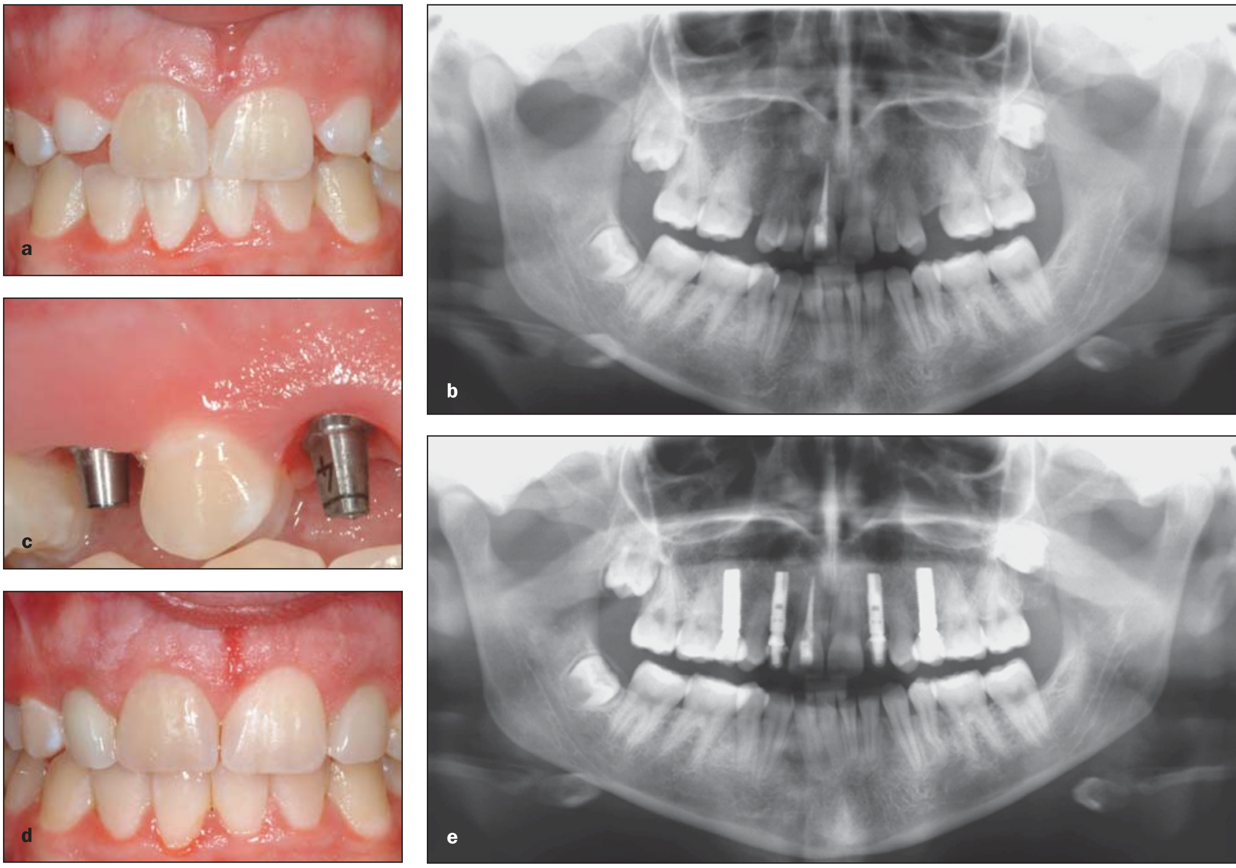


Fig 5 Immediate loading of maxillary incisors and premolars. *(a)* Preoperative clinical photograph demonstrating pericoronal tissue architecture. Implant depth of placement dictates soft tissue profile at lateral incisors and their esthetic relationship to the central incisors and canines. *(b)* Preoperative radiograph indicating an ideal osseous situation for immediate loading of the missing second premolar and retained primary canine/missing lateral incisor. *(c)* Ten-week postoperative clinical appearance of right maxillary implants following immediate provisionalization of the second premolar and lateral incisor. Note the shallow placement of the clinical crown margin (abutment). *(d)* Ten-week postoperative clinical appearance of maxillary lateral incisor crowns. The soft tissue architecture was dictated by the depth of implant placement. *(e)* Ten-week postoperative panoramic radiograph reveals the positions of the implants and the placement of the titanium abutments relative to the alveolar bone height at adjacent teeth.

esthetics[25] and can be affected by the superimposed prosthesis design and materials. In this study, all implants were provisionalized using titanium or aluminous ceramic abutments. Based on reports of peri-implant mucosal responses to different materials,[22] the abutment materials permit establishment of a connective tissue contact and junctional epithelium along the abutment surface.

Other component-related issues include the use of unitary designs that lack an implant-abutment interface and micromotion potential (but require surgical placement of the restorative margin) and the use of conus-design modular implants (as illustrated here). The latter also prevent micromotion and offer little or no potential for retrograde bacterial contamination and inflammation at the interface during healing. All provisional restorations were cemented over abutments, leaving no access to the screw.

This concept of establishing the biologic width along the abutment as a clinical procedure may be used to define or to predict the esthetic features of the peri-implant tissues following healing (Fig 5). In addition to controlling the depth of implant placement and limiting trauma to peri-implant tissues and bone, this response is further subject to clinical control by the use of highly polished and appropriate materials, the absence of intervening cement or residual restorative materials, and placement of the restorative margin (cemented or screw-retained) a minimum distance of 2 mm from the implant-abutment interface so that it is coincident with the implant-bone marginal interface. When these conditions exist, there is a high probability of creating and maintaining existing papilla.

CONCLUSIONS

- Immediate tooth replacement using immediate placement and provisionalization of dental implants offers many advantages, including predictable maintenance of peri-implant mucosal structure.
- Implant placement considerations include assurance of stability and restorability; depth of placement should not jeopardize proper biologic width formation or establish a potential anaerobic environment.
- Implant component selection should *(a)* promote interfacial bone formation and preservation of crestal bone and *(b)* preclude inflammation in the healing peri-implant mucosa.

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