Influence of Immediate Implant Loading on Peri-implant Soft Tissue Morphology in the Edentulous Maxilla

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Purpose: *This study investigates the pre- and posttreatment morphology of the mucosa around immediately loaded implants in the edentulous maxilla.* ***Materials and Methods:*** *Implants were placed and immediately loaded in edentulous maxillae; pre- and posttreatment impressions were obtained. The resulting casts were digitalized into 3-dimensional images, and the pre- and posttreatment images were superimposed. The width and height of the maxillary alveolar process were measured at central and interproximal implant sites in a vertical section of the superimposed holograms. For statistical analysis, the Delta value (d) was defined as the difference between the pre- and posttreatment images for all measurements.* ***Results:*** *Sixty-seven Straumann implants placed in 9 patients and immediately restored with provisional fixed restorations were analyzed. An increase in width at all measurement sites was observed after treatment. Width increased for both central implant (1.51 ± 1.16 mm,* $P < .001$*) and interproximal implant sections (1.02 ± 1.21 mm,* $P < .001$*). Mean d for height was found to be decreased at central implant sites (−1.21 ± 1.67 mm,* $P = .012$*) and at interproximal sections (−0.72 ± 1.68 mm,* $P = .098$*).* ***Discussion and Conclusion:*** *Clinically, it has been observed that the placement of an immediate provisional affects the peri-implant tissue morphology according to its emergence profile. The result after treatment was a wider contour of the peri-implant soft tissue, located in a more apical position than the original mucosal level. The most coronal part of the papilla-like mucosa at interproximal sites would be nearest to the original mucosal level before treatment. The scalloped mucosal configuration obtained was consistent along the rehabilitated arch. Statistically significant dimensional changes of the peri-implant mucosa were observed with an immediate loading approach.* (Clinical Trial) INT J ORAL MAXILLOFAC IMPLANTS 2007;22:595–602

Key words: *dental implants, edentulous maxilla, immediate loading, papilla-like mucosa, peri-implant soft tissue, scalloped mucosa, screw-retained provisional prostheses*

Clinical research on the treatment of edentulous jaws with fixed implant-supported restorations has shown predictable long-term results.[1–4] Projections based on epidemiologic data show that in 2010 nearly 21 million middle-aged adults (aged 35 to 64) will be edentulous in 1 or both arches.[5] Patients who lose their dentition early in life are highly likely to receive fixed dentition, although socioeconomic aspects could be a limiting factor.[6,7]

The term *immediate loading* has been used to designate dental implants subjected to occlusal functional load immediately after implant placement.[8,9] The main advantage of treating edentulous patients with fixed immediate provisional prostheses is elimination of the need for a removable prosthesis after surgery.[10–14] Clinical reports on immediate loading have provided compelling long-term evidence for both maxillary and mandibular implants.[15–29]

In spite of the long-term implant survival rate, fixed implant prostheses for the edentulous maxilla have been associated with speech disruptions and

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compromised esthetic appearance.[30,31] Given the flat U-shaped morphology of the edentulous maxilla, achieving a harmonious relationship between a fixed prosthesis and scalloped peri-implant tissue could be challenging. Consequently, some authors have proposed that a scalloped mucosal contour could be obtained using an immediate loading technique.[32–34] However, the extent of such scalloping in peri-implant mucosa is yet to be scientifically verified.

This study investigates the pre- and posttreatment morphology of the mucosa surrounding immediately loaded implants in the edentulous maxilla. The working hypothesis was that there would be statistically significant dimensional changes and that they would be conditioned by the host, the measurement site, or the implant position in the edentulous arch. The null hypothesis was that there would be no soft-tissue dimensional changes with an immediate loading approach.

MATERIALS AND METHODS

Nine patients in need of a fixed implant-supported restoration in the edentulous maxilla were enrolled in this study. The inclusion criteria were:

- Edentulous maxilla with enough bone (native or previously grafted) to receive implants with a minimum length of 8 mm
- Presence of keratinized mucosa at the buccal aspect of the edentulous maxilla
- Placement of 8 to 10 implants distributed in the dental arch to reach the first molar region
- Delivery of a screw-retained provisional prosthesis within 24 hours following implant surgery

At baseline, an alginate impression of each edentulous maxilla was made and poured within 30 minutes. The resulting diagnostic cast was coded with the patient's initials and stored; this cast was considered the pretreatment cast (T1). All patients were treated according to the same immediate loading protocol according to the "pickup technique."[24] After a functional healing period of 4 months, and before the final impressions, a custom tray was used to reproduce the soft tissue status. The screw-retained provisional prostheses were loosened and kept in place to avoid the collapse of the peri-implant mucosa until the impression was made. Immediately after the provisional prosthesis was retrieved, a low-viscosity polyvinyl siloxane (PVS) impression material was injected onto the implants and the surrounding peri-implant tissues with a manual dispenser. This first application of low-viscosity PVS was gently blown around the implant sites to uniformly spread a thin layer of impression material. A similar mixer device was used to simultaneously load the custom tray, this time using a heavy-body PVS. The custom tray with the heavy-body paste was then inserted into the mouth and centered to the patient's facial midline until the palatal stops contacted the palatal mucosa. Dental stone (GC Fujirock EP; GC Europe, Leuven, Belgium) was used for fabrication of posttreatment casts (T2).

Three-dimensional Cast Superimposition and Digital Analysis

Eighteen casts (pre- and posttreatment cases obtained from 9 patients) were digitized using a 3-dimensional (3D) surface laser scanner (Laserscan 3D Pro; Willytec, Gräfelfing, Germany). After stabilization on a special base, a monochromatic slit laser beam was projected onto the occlusal surface. The laser light was diffracted on the cast surface, producing a "Fresnel" diffraction pattern,[35] which was observed at a defined angle by a high-resolution charge-coupled device (CCD) camera. The image was then transferred through a video acquisition system to a personal computer controlled by the SCAN-3D software (Willytec). The pre- and posttreatment 3D images were recorded in individual patient files.

Pre- and posttreatment 3D images of each patient were then digitally matched. The 3D data included well-defined areas that appeared identical in both images, so-called "superimposition areas." The pre- and posttreatment 3D images were superimposed on a predefined polygonal area in the palate that denominated the matching area (Ma in Fig 1). The area selected for matching included the third palatal rugae and the palate along the midline raphe to the post dam region. This zone of the palate was used because *(1)* it was reproducible, *(2)* it was unmodified during surgery, and *(3)* it significantly enhances the reliability of the 3D superimposition.[36] The fusion of the 2 original holograms after their superimposition resulted in a new hologram containing of both the pre- and posttreatment 3D images. The percentage of positive matching at the selected area and its standard deviation were individually recorded for each matched hologram.

Measurements

The width and height of the maxillary alveolar process were measured in a slice window tool (SCAN-3D software; Willytec) screening a vertical section of both superimposed before and after holograms (Fig 1). Sixty-seven sections were measured on the pre- and posttreatment matched holograms at the central implant (Fig 1). One hundred sixty-eight sections

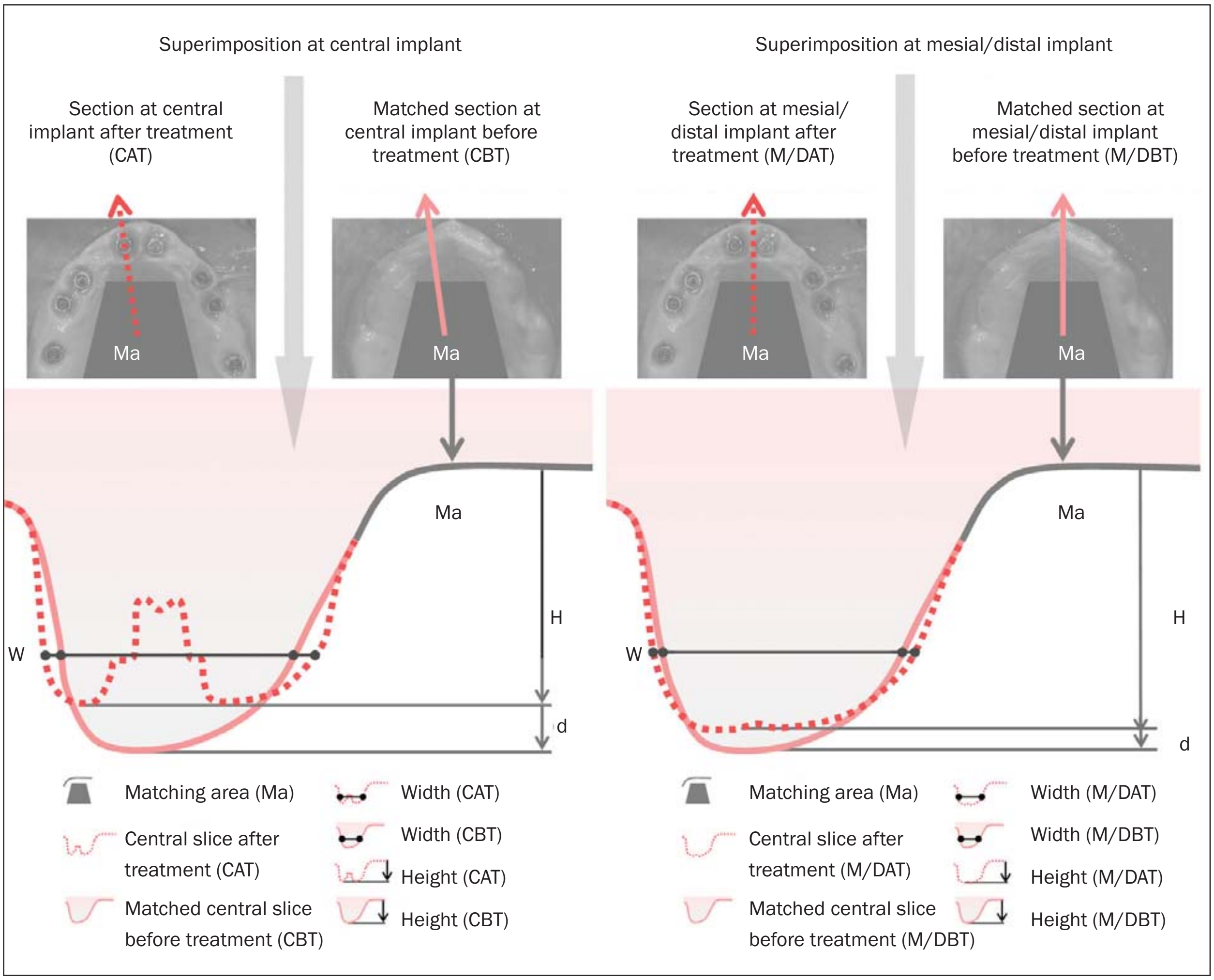


Fig 1 Digital images obtained pre- and posttreatment to compute matching areas, sections, and superimposition. *(Top)* Occlusal views of pre- and posttreatment holograms matched at either the central *(left)* or mesial/distal *(right)* implant. Polygons indicate the matching area. *(Middle)* Slice window screening vertical sections of the superimposition of the pretreatment and posttreatment holograms. *(Bottom)* Items composing the superimpositions at central and mesial/distal sections and related measured distances.

were measured on the pre- and posttreatment matched images at mesial or distal implant (Fig 1). Width value (W) was defined as the distance connecting the most buccal with the most palatal point at the coronal third of the alveolar process. The height value (H) was defined as the distance connecting the most apical point of the palatal raphe with the most coronal point of the alveolar process. For statistical analysis, the delta value (d) was defined as the difference T2–T1 for all measurements under study. The accuracy of method used in this study was previously described in similar investigational work.[37]

Statistical Analysis

A paired *t* test was employed to analyze dimensional soft tissue changes after the placement of immediately loaded implants. Multifactor analysis of variance (MANOVA) was used to investigate the effect of 2 factors (central versus interproximal measurement site and anterior versus posterior implant position) on the width and height of the peri-implant soft tissue after immediate implant placement. The fact that there were multiple implant hosts was incorporated into the ANOVA by setting the patient as a random factor in the model to investigate the existing variability among patients. The level of significance was set at $\alpha = .05$.

Table 1 Mean Differences in Width and Height for All Patients

		Difference in width (mm)*				Difference in height (mm)*			
Patient	No. of sites	Interproximal	Central	Anterior	Posterior	Interproximal	Central	Anterior	Posterior
TM	22	1.09	1.45	1.22	1.14	0.93	−0.06	0.99	0.08
PJ	28	1.10	1.06	1.22	0.95	−0.55	−0.74	−0.60	−0.61
BM	28	0.07	0.61	0.43	0.19	−0.86	−1.64	−0.49	−1.67
CM	28	0.13	0.79	0.60	0.04	−0.55	−0.91	−1.17	−0.13
FJ	26	2.40	3.17	2.66	2.58	−2.08	−2.64	−1.95	−2.60
AJ	27	0.52	0.76	0.49	0.68	−2.13	−2.42	−3.90	−0.40
MM	22	1.85	2.61	2.31	1.62	0.19	−0.13	0.39	−0.41
MA	23	1.08	1.62	1.28	1.20	−1.91	−2.04	−2.01	−1.86
PM	28	1.27	1.76	1.41	1.41	0.54	0.17	-0.04	0.91
Total	232	1.02 ± 1.21	1.51 ± 1.16	1.29 ± 1.10	1.01 ± 1.31	−0.72 ± 1.68	−1.21 ± 1.67	−0.98 ± 1.72	−0.72 ±1.65
Paired *t* test		.004	< .001	.001	.005	.098	.012	.084	.076

*Pretreatment value subtracted from posttreatment value.

Table 2 MANOVA Results (*P* value)

Experimental factors	Difference in width	Difference in height
Host	.001	< .001
Central/interproximal site	.001	.006
Anterior/posterior site	.385	.393

RESULTS

A total of 232 sites around 67 Straumann implants (Straumann, Basel, Switzerland) were analyzed from 9 edentulous maxillae with fixed immediate restorations. In all patients, implants were distributed equally in the anterior and posterior segments of edentulous maxilla.

The mean percentage of accuracy in matching areas was 91.22% ± 0.67% for the pre- and posttreatment matched holograms.

Statistical analysis showed an increase of width at all measurement sites at T2 (Table 1). Both central implant (1.51 ± 1.16 mm, $P < .001$) and interproximal implant sections (1.02 ± 1.21 mm, $P < .004$) became wider. Both anterior (1.29 ± 1.10 mm, $P < .001$) and posterior (1.01 ± 1.31 mm, $P = .005$) sites were found to be wider at T2.

A decrease in the mean height was observed, but this was statistically significant only in the case of the central implant sites (–1.21 ± 1.67 mm, $P = .012$). For mean difference of height at interproximal sections (–0.72 ± 1.68 mm, $P = .098$), the null hypothesis could not be statistically rejected.

MANOVA revealed that both width and height values observed were affected by the host (variability between patients) and the measurement site (central versus interproximal; Table 2). This, however, was not the case for anterior versus posterior measurements.

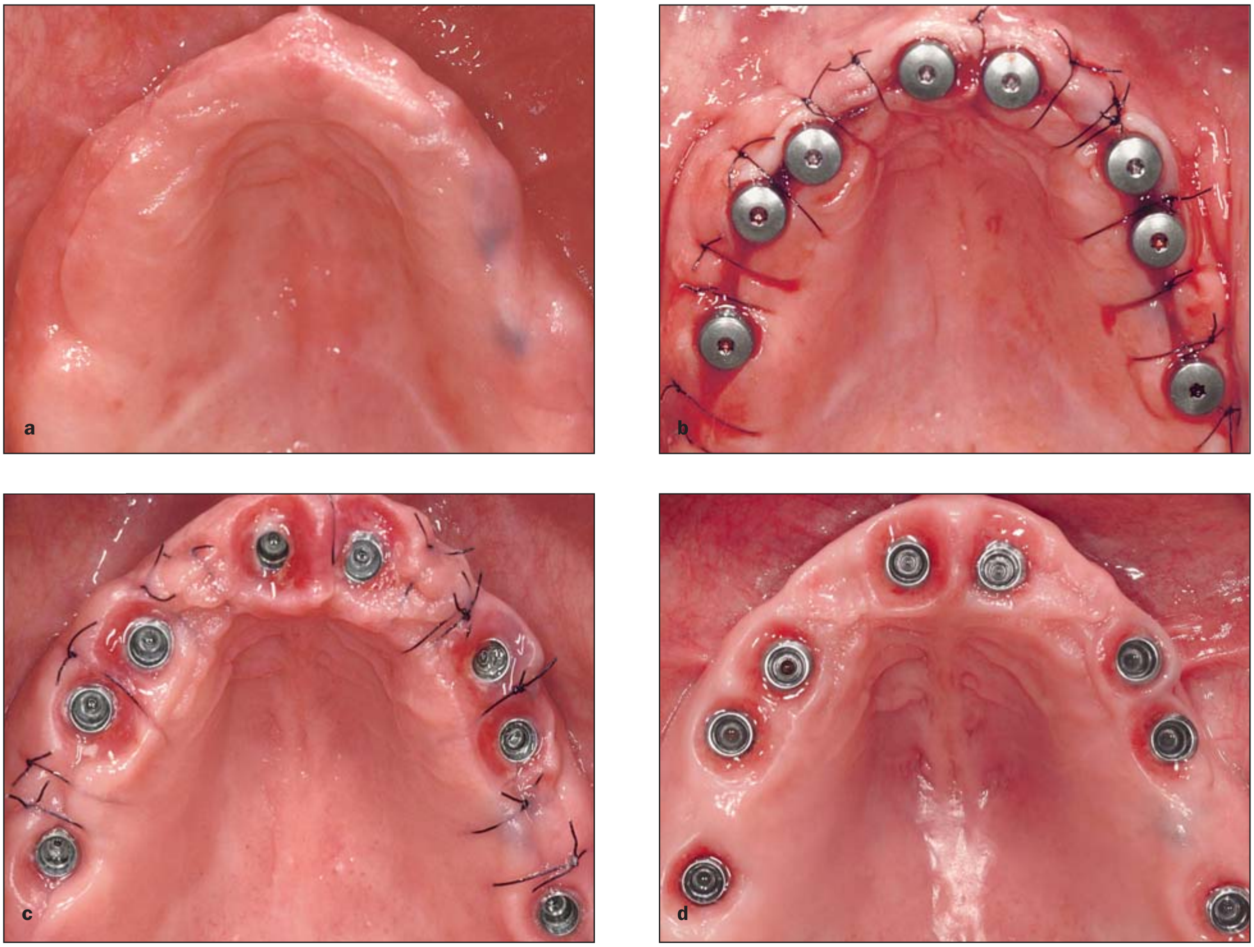
DISCUSSION

Esthetic implant restorations have seen rapid development in the last decades. However, a literature review assessing implant restorations in the anterior maxilla has demonstrated that scientific evidence of esthetically relevant and reproducible parameters is rather scarce.[38] Today, patients' high esthetic demands call for special attention in the treatment of the partially edentulous anterior maxilla with dental implants.[39]

Achievement of esthetic integration in the edentulous maxilla should be planned using the same parameters used with partially edentulous patients. Prosthodontic proposals for implant-supported fixed restoration of the edentulous maxilla include full-arch hybrid prostheses.[1,31,40] Although they effectively address interarch discrepancies, prosthetic teeth arrangement, and lip support, they have also been associated with serious speech disruptions.[30,31,41–43]

Implant-supported metal-ceramic restorations in the edentulous maxilla can prevent verbal communication and discomfort and offer enhanced esthetic integration.[44–48] Proper development of gingival contours mimicking healthy natural dentition can improve the esthetic appearance of implant-supported fixed prostheses. However, this approach has been reported as often difficult to achieve in the completely edentulous maxilla.[32,33,49]

The observational design presented in this study was created to increase understanding of the soft tissue changes before and after immediate implant loading. These changes of the edentulous maxillary mucosa are presented in Figs 2a to 2d. Clinically, it has been observed that the placement of an immediate provisional prosthesis reshapes the peri-implant tissue according to the emergence profile created at the cervical aspect of the provisional prosthesis. This



Figs 2a to 2d Evolution of peri-implant soft tissue healing of an edentulous maxilla with immediate implant loading. *(a)* Occlusal view of an edentulous maxilla before treatment. From this clinical situation, an alginate impression was obtained to record the pretreatment status. *(b)* Clinical view immediately after surgical placement of 8 implants. Implants were strategically distributed according to the final prosthetic protocol. Healing abutments kept the mucosal flap away from its original location when sutures were performed in a nonsubmerged approach. *(c)* Maxillary peri-implant soft tissue appearance after retrieval of the screw-retained provisional prosthesis. *(d)* Status of the peri-implant mucosa after 4 months of functional healing. At this stage, a PVS impression was obtained to record the posttreatment condition.

becomes particularly important when interdental papillae need to be created from a flat mucosa (Fig 2a) to achieve harmonious integration of prosthesis and the peri-implant tissues.[24] Although this is generally accepted, the extent of such changes has not yet been scientifically investigated. The reliability of the model used in this investigation has been previously assessed in a similar experiment.[37] Furthermore, the matching process (91.22% ± 0.67%) allowed for measurements of pre- and posttreatment sections at the same location. Data presented in this study were independently measured in a slice window tool (SCAN-3D software; Willytec, Gräfelfing, Germany) at central and interproximal implant sites. Subsequently, the D value (difference in width and height between pre- and posttreatment) was statistically calculated.

In the case of width measurements, the hypothesis that there would be significant dimensional changes could be statistically confirmed. The D value for width between T1 and T2 was higher at the central implant (CAT in Fig 1) than at interproximal sites (M/DAT in Fig 1; $P < .001$, Table 2). A widening of 1.51 mm was observed at the implant level, versus 1.02 mm interproximally. Width value showed a relatively equal distribution at the buccal and the palatal sides. This widening could be attributed to 2 different treatment stages. First, at the time of surgery, a midcrestal incision was performed, and implants were placed. With an immediate loading approach, suturing should ideally be performed around the implant healing abutments in a nonsubmerged approach (Fig 2b). It seemed evident that interposition at suturing would interfere with the flap repositioning, which would keep the mucosa slightly away from its initial location at central implant level. On the other hand, the sutures at the interproximal level were kept for at least 10 days, almost completely closing the incision.

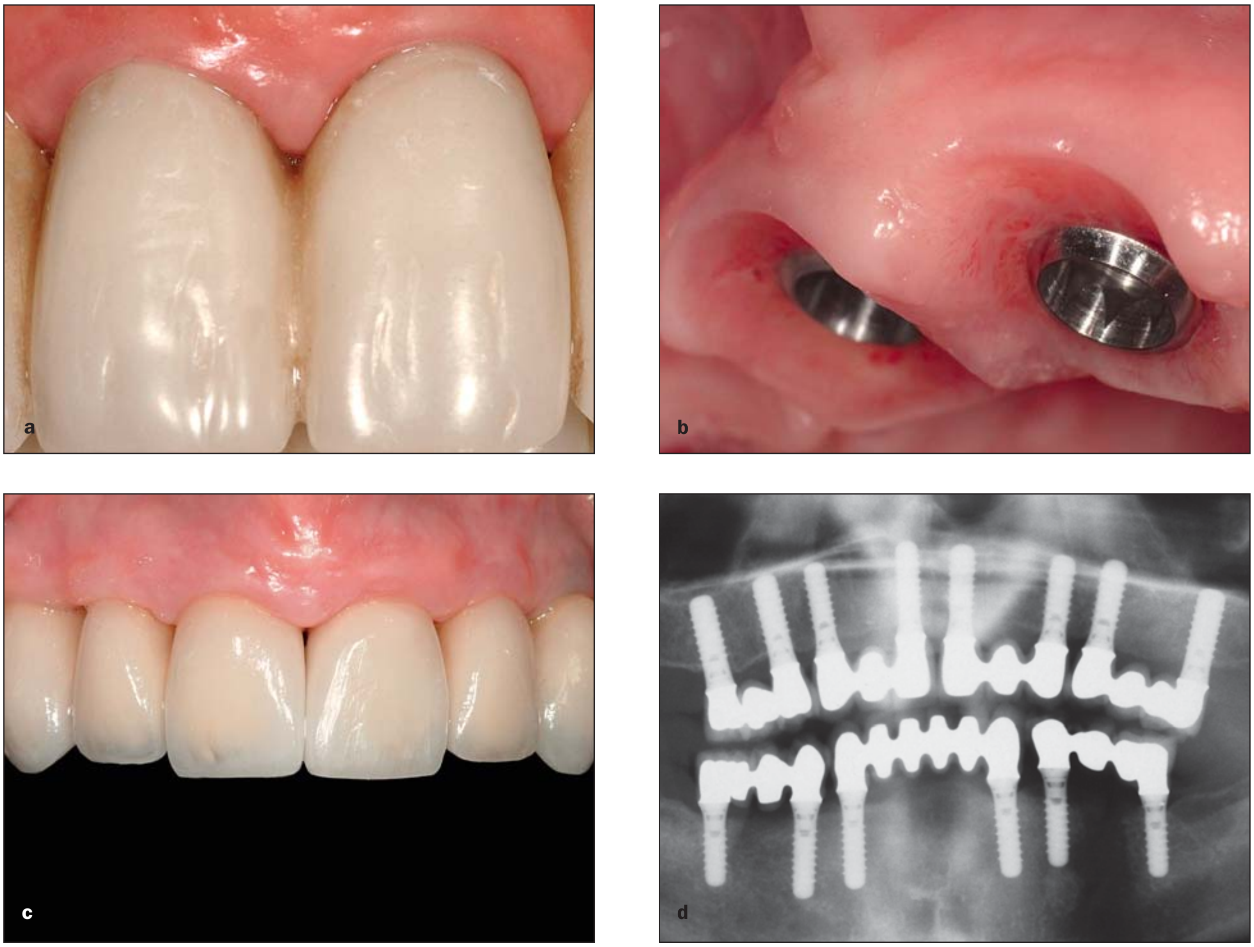


Fig 3 Clinical and radiographic status of definitive restoration, including scalloped peri-implant mucosa. *(a)* Frontal view of the immediate provisional restoration after 4 months of functional healing. The peri-implant soft tissue contour followed the cervical configuration of the provisional prosthesis. The mucosal level was apically displaced, whereas at interproximal level the papillalike mucosa occupied the embrasure space. This papillalike mucosa corresponded to the closest level of the original mucosa before treatment. (*b)* The peri-implant mucosa at the time of the posttreatment impression. After removal of the provisional prosthesis, the scalloped configuration of the mucosa and capillary vascularization of the peri-implant area could be observed. *(c)* Anterior image of the definitive ceramic restoration. The cervical configuration of the definitive restoration should ideally integrate with the previously reshaped peri-implant soft tissue. *(d)* Radiographic follow-up at seating of the full-arch segmented fixed restoration.

Second, in this clinical trial, all provisional prostheses were delivered the day of implant placement. At the time of immediate fixed provisional seating, a blanching was observed at the mucosal level in all patients. This is an indicator that insertion of the provisional prosthesis modified the final position of the sutured mucosa. The cervical area of the provisional prosthesis was created with a natural-looking emergence profile, presenting a well-defined opening for the respective embrasures. It was observed that after 2 weeks, when the provisional prostheses were retrieved for suture removal (Fig 2c), the peri-implant mucosa had copied out the provisional emergence profile. The configuration adopted by peri-implant mucosa remained stable as long as the provisional prostheses were kept in place or their embrasures were not modified (Fig 2d).

For vertical measurements, the D value for height was always smaller at the central implant than at interproximal areas. This finding was clinically observed at the formation of papillalike mucosa with a scalloped feature along the rehabilitated arch (Figs 3a to 3d). The hypothesis was statistically confirmed for difference in height at the central implant; a statistically significant change in peri-implant mucosa height occurred after implant placement and immediate loading of provisional prostheses. The configuration of the cervical aspect of the provisional prostheses plays an important role in shaping the peri-implant mucosa. Since the most apical point of this cervical zone is aligned with the implant location, any soft tissue remaining in this area after suturing would be displaced by the insertion of the screw-retained provisional prosthesis. Meanwhile, at the interproximal areas, the sutures would guide the flap edges to occupy the embrasure spaces during the healing process (Fig 3a). For the D value of height at the interproximal areas, the null hypothesis could not be statistically rejected. These data suggest that although vertical changes at the mesial/distal implant level occurred, they were not sufficient to confirm the hypothesis.

The mean D values for height at interproximal and central implant sites were negative (–0.72 and –1.21 mm, respectively; Table 1). This means that the contour of the peri-implant mucosa was found in a more apical location posttreatment. The most coronal part of the papillalike mucosa at interproximal sites would be nearest to the original mucosal level before treatment (Fig 3b). However, while this statement is valid for the overall mean difference in height, it is not the case when patients are observed independently (Table 1). Many factors, including thickness of the keratinized mucosa, suturing technique, and opening of provisional embrasures, could affect the final position of the mucosal contour. The implant shoulder should be located slightly below mucosal level to allow the provisional prosthesis to scallop the peri-implant mucosa. The embrasure opening will determine the length of the papillalike mucosa. However, it has been observed that additional enlargement of the embrasures does not increase the length of the interproximal mucosa.

Clinically, the scalloped mucosal configuration obtained was consistent along the rehabilitated arch. Consequently, the influence implant position (anterior versus posterior implant distribution) was not considered relevant.

CONCLUSIONS

Dimensional changes in the width and height of the peri-implant mucosa were observed with immediate loading. They were more important at the central implant level than at interproximal (mesial/distal) sites, but they did not seem affected by implant location (anterior or posterior). These dimensional changes may vary among patients. The width of the peri-implant mucosa (coronal third) after delivery of immediate implant-supported provisional prostheses appears greater than before treatment at the central and interproximal implant sites, respectively. Height appeared to decrease at the central and interproximal implant sites.

The cervical configuration of the immediate provisional prostheses and the respective embrasures appears to be responsible for the peri-implant mucosa shape during the healing phase.

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