# Tissue Dimensional Changes in Single-Tooth Immediate Extraction Implant Placement in the Esthetic Zone: A Retrospective Clinical Study

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***Purpose:*** *The aim of this study was to evaluate the buccopalatal volumetric tissue change that occurs following flapless single-tooth immediate extraction placement in the esthetic area and to analyze the role of four different variables.* ***Materials and Methods:*** *Patients in need of a single-tooth replacement in the anterior maxillary or mandibular area (premolar to premolar) were recruited for the study. Patients were treated using four different therapeutic modalities: group 1 (healing abutment), group 2 (healing abutment + bone graft), group 3 (provisional restoration), and group 4 (provisional + bone graft). Alginate impressions were taken the day of implant insertion before tooth extraction (T0), at 1 month (T1), at 3 months (T2), and at 6 months (T3). Buccopalatal dimension (BPD) was measured on the study casts at 1, 3, and 5 mm apical to the free gingival margin and compared between T0 and T1 and T2 and T3.* ***Results:*** *Seventy-seven patients were included in the study, 29 men and 48 women with a mean age of 54 years (range: 24 to 76 years), and 80 implants were inserted. Thirteen implants were inserted in group 1, 13 in group 2, 20 in group 3, and 34 in group 4. The BPD contraction was more evident for group 1, smaller in group 2 and group 3, and minimal in group 4. Repeated measures analysis of variance (ANOVA) and post hoc tests were used. The data analyzed were considered statistically significant with a level of* $\alpha = .05$*. The interaction effect P value was numerically zero.* ***Conclusion:*** *The results of this study seem to indicate that volumetric tissue changes after immediate extraction placement in the esthetic area can be minimized if a provisional is immediately connected and a bone graft is inserted simultaneously.* INT J ORAL MAXILLOFAC IMPLANTS 2018;33:439–447. doi: 10.11607/jomi.6146

**Keywords:** *flapless, immediate implant placement, single tooth, tissue dimensional changes*

A number of developments have made treatment with dental implants more predictable, including better understanding of the biology of peri-implant soft and hard tissue healing, more knowledge of the interaction between implant surfaces and the surrounding tissues, and new surgical techniques.[1–3] Traditionally, the standard protocol for replacing a hopeless tooth called for 2 to 3 months of bone healing after extraction,[4,5] followed by implant placement and 3 to 6 more months of load-free healing to allow for osseointegration.[6,7] In the late 1970s, the concept of placing the implant immediately after extraction was introduced.[8] This was shown to have several advantages and no adverse effects compared with the standard staged procedures. In more recent decades, a change in the protocol had been suggested to improve the technique.[9,10] To reduce the discomfort of wearing a removable provisional restoration during healing, the application of a one-stage surgical procedure with immediate insertion of a fixed restoration has been suggested.[11] In clinical practice, immediate loading procedures were first used to rehabilitate the complete edentulous mandible.[5] The high success rate obtained there encouraged extension of the immediate loading protocol to single-tooth cases.[12] As an alternative to a two-stage surgical protocol in the esthetic zone,[1,13] the application of a one-stage flapless approach with the immediate connection of a provisional restoration[13,14] has been suggested.

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Studies have shown that survival rates for immediately provisionalized single-tooth implants are comparable to those placed with the delayed (staged) approach; the only limitation has been the esthetic outcome.[7]

Dimensional ridge changes following tooth extraction have been documented by several studies.[9,10] Animal studies have clearly shown that tooth extraction determines remodeling and consequent changes in the alveolar bone architecture.[15,16] Both the buccal and lingual alveolar crest undergo substantial resorption of the bony walls, with resulting vertical reduction of the alveolar crest dimension. This resorption occurs mainly on the buccal side and can compromise the final esthetic outcome.[16] Although it has been suggested that implant placement into fresh extraction sockets might prevent bone ridge changes,[17] recent clinical studies have failed to support this but have shown that the width of the buccal bone crest can influence its resorption pattern.[18]

Because of the discrepancy between the tooth root anatomy and the implant geometry, an implant-to-bone buccal gap typically results when implants are inserted immediately following tooth extraction. The difference in the shape between the root and the implant may represent a challenge for the operator.[19]

The aim of the present study was to evaluate the horizontal dimensional changes at single-tooth extraction sites in the esthetic zone after flapless immediate implant insertion and one of four different therapeutic choices: connection of a healing abutment or a provisional restoration, with or without simultaneous bone grafting.

## MATERIALS AND METHODS

Between February 2011 and March 2015, patients at one private dental clinic in need of single-tooth replacement in the mandibular or maxillary anterior zone (incisor, canine, and premolar area) were considered for inclusion in the study. All study subjects had to be at least 20 years of age and provide written informed consent before participating.

Both smokers and nonsmokers were included. Patients with systemic disorders that precluded surgical treatment were excluded, as were those with severe maxillo-mandibular discrepancies and/or active pathology of the adjacent teeth. The inclusion criteria required intact alveolar walls; patients with a bone defect in the buccal wall were excluded from the study. However, the presence of a periapical lesion at the extraction site was not considered to be cause for exclusion as long as the alveolar bony walls were intact. Other inclusion criteria were as follows: the presence of a single tooth with a hopeless prognosis due to decay, endodontic failure, or fracture; preservation of intact alveolar walls after the extraction; the possibility to place an anatomically tapered, screw-shaped implant immediately after extraction of the hopeless tooth; achievement of primary stability; and sufficient interarch space to allow for restoration with anatomically sized crowns. Patients were divided into two categories based on the level of implant primary stability the day of insertion. Patients received a healing abutment and a removable provisional prosthesis if the immediately inserted implant had a low to medium (< 50 Ncm) insertion torque. Patients received a fixed provisional prosthesis if the immediately inserted implant had a medium to high (≥ 50 Ncm) insertion torque. Patients belonging to the first category (healing abutment) were then divided into two groups: group 1, no graft; and group 2, graft. Whether to use the graft or not was randomly selected for the first patient, and from then on, alternating the two options in order to have an equal sample size.

Patients belonging to the second category (immediate fixed provisional prosthesis) were then divided into two groups: group 3, no graft; and group 4, graft). Whether to use the graft or not was randomly selected. Patients were previously informed about the options.

### Surgical Procedure

A thorough intraoral examination was given to each patient as well as a full periodontal examination (biotype examination, probing, and periapical radiographs), and a cone beam computed tomographic (CBCT) scan was taken to enable precise evaluation of the alveolar bone anatomy at the extraction site. Study casts were mounted on an articulator, a diagnostic wax-up was made, and an acrylic resin provisional prosthesis and surgical template was fabricated.

Three to four days before the surgery, the patient was prepared with an oral hygiene session and instructed to use 0.20% chlorhexidine rinse three times a day for 14 days. Twenty-four hours before the surgery, the patient was started on antibiotic prophylaxis with amoxicillin 1 g, one tablet twice a day for 6 days. Local anesthesia was induced with articaine 4% with adrenaline 1:100,000 in the vestibular and lingual areas. The tooth was atraumatically extracted, keeping the alveolar walls intact with a flapless approach at all sites. In accordance with the manufacturer's protocol, the drilling sequence was followed, applying a slight modification in the use of the last drill in order to underprepare the diameter of the osteotomy to improve primary stability. This was accomplished by using a final drill that was one size shorter than the actual implant length. The implant was placed, and final seating was obtained using a calibrated torque hand ratchet (Biomet 3i). Only tapered implants were used in the study (Biomet 3i).

Whenever the insertion torque was lower than 50 Ncm, a healing abutment (Biomet 3i) was connected. In all other cases, the implant was immediately provisionalized.

Temporary abutments (Preformance, Biomet 3i) that were platform-switched were placed and then joined to a provisional shell using a light-cured composite resin (Tetric-Flow, Ivoclar Vivadent). The occlusion was adjusted to leave the provisional prosthesis out of occlusion. Whenever possible, the crown of the natural tooth was hollowed out and luted to the temporary cylinder to serve as a provisional prosthesis.

The distance between the buccal wall and the implant was measured in every site. The decision of whether to graft the facial area or not was made alternating a grafted site to a nongrafted site in order to have an equal sample size. The particulate graft consisted of a 50-50 mixture of autogenous bone harvested during drilling with the fluted burs and bovine xenograft particulate material (0.5 to 1.0 mm Endobon, Biomet 3i). It was inserted in the buccal and interproximal areas of the alveolar bone-to-implant gap. The screw-retained provisional prosthesis was inserted and torqued to 10 Ncm for the final seating following the manufacturer protocol with a calibrated torque hand-ratchet (Biomet 3i).

Figures 1 to 13 show the clinical procedure.

Patients were alternatively selected to be part of a group and divided into four categories:

- Healing abutment only (13 implants)
- Healing abutment + graft (Autogenous Bone + Endobon, Biomet 3i) (13 implants)
- Provisional restoration only (20 implants)
- Provisional + graft (Autogenous Bone + Endobon, Biomet 3i) (34 implants)

Figure 14 shows the four different categories.

Patients were instructed to maintain a liquid diet exclusively for the first week and to refrain from chewing on the implant-retained crown for the first 8 weeks. All patients returned weekly throughout the first month after surgery for examination and hygiene maintenance.

### Measurements

To evaluate the volumetric tissue changes during healing, alginate impressions of each treated site were made and poured in white orthodontic gypsum within 1 hour to obtain study casts at the following intervals: before the extraction (Time 0), at the 1-month follow-up appointment (Time 1), at the 3-month follow-up (Time 2), and at the 6-month follow-up (Time 3). Treated sites on the study casts were marked at the 1-, 3-, and 5-mm levels from the free gingival margin both on the buccal and palatal sides using millimeter-calibrated paper stickers (Fig 15). The distance between the buccal and palatal marks at each of the three levels on the casts made for each patient at each time point was measured to a tenth of a millimeter using an electronic digital caliper (Aura-Dental). The operator chosen for cast measurements used a ×4.3 eye magnification optical loupes with headband (Zeiss EyeMag Pro S). In order to minimize the measurement error, all measurements were taken by the same operator, three times for each landmark at each time interval.

After 6 months, a final impression was made using a custom tray, a pick-up coping (Biomet 3i), and a low-viscosity polyether (Impregum Penta 3M). A gold UCLA abutment (GUCA, Biomet 3i) was used in all the cases. Definitive restorations were screw-retained, and the abutments were torqued to 20 Ncm for internal connection or 32 Ncm for external connection with a calibrated torque driver (Biomet 3i) following the manufacturer's recommended prosthetic protocol.

## RESULTS

A total of 77 patients (29 men and 48 women) were recruited to participate in the study. Three patients received an implant at two separate sites. The remaining 74 patients each received one implant. Figure 16 details the implant distribution.

Based on the initial implant stability that was achieved and the randomization procedure that was applied to determine which patients would receive grafting procedures, the total of 80 implants were distributed in the following four groups:

- Group 1: Healing abutment—13 implants
- Group 2: Healing abutment + graft—13 implants
- Group 3: Provisional restoration—20 implants
- Group 4: Provisional + graft—34 implants

Analysis of the horizontal dimensional changes, as measured on the study casts, yielded the following results.

Implants in group 1 exhibited the greatest amount of horizontal shrinkage.

Tables 1 to 4 have been obtained by post hoc analysis on the repeated measures analysis of variance (ANOVA) models as described in the methodology section. Differences between level effects, corresponding standard errors (SE), and *P* values are shown.

Table 1 shows the mean horizontal dimensional reduction at the three levels 1, 3, and 6 months after placement of the group 1 implants and their healing

**Fig 1** Frontal view of the six maxillary anterior teeth.


**Fig 2** *(Left)* Initial CBCT cross section of the fractured left maxillary incisor.

**Fig 3** *(Below)* The tooth after a flapless atraumatic extraction.

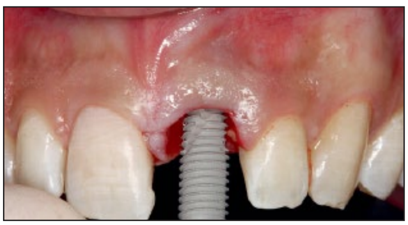


**Fig 4** Frontal view of the tapered implant insertion.

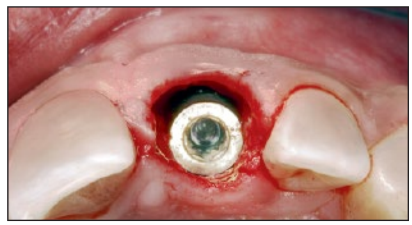


**Fig 5** Occlusal view of the inserted implant.

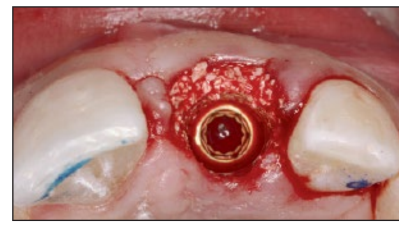


**Fig 6** The buccal gap was grafted with a 50:50 mixture of autogenous bone and xenograft.

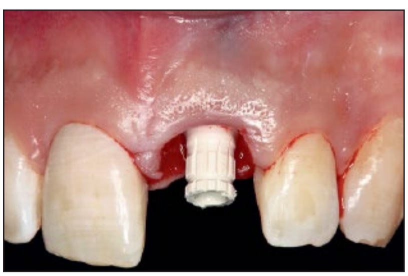


**Fig 7** Peek temporary cylinder inserted.



**Fig 8** *(Left and Above)* The natural crown was hollowed out to be used as provisional.

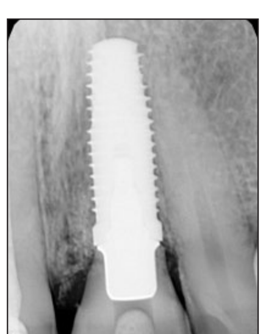
**Fig 9** Screw-retained provisional prosthesis insertion.

**Fig 10** Frontal view of the immediate restoration.

**Fig 11** Frontal view of the definitive prosthesis at 1-year follow-up.

**Fig 12** Buccal profile at 1-year follow-up.

**Fig 13** Radiograph of control at 1-year follow-up.



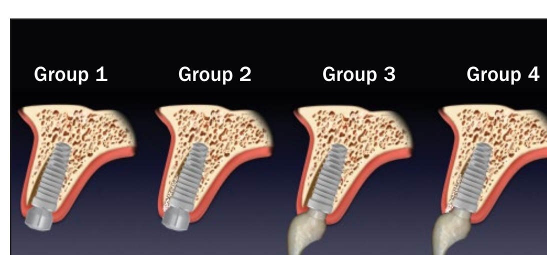



**Fig 14** The four different categories: group 1: healing abutment; group 2: healing abutment + buccal graft; group 3: provisional; group 4: provisional + buccal graft.

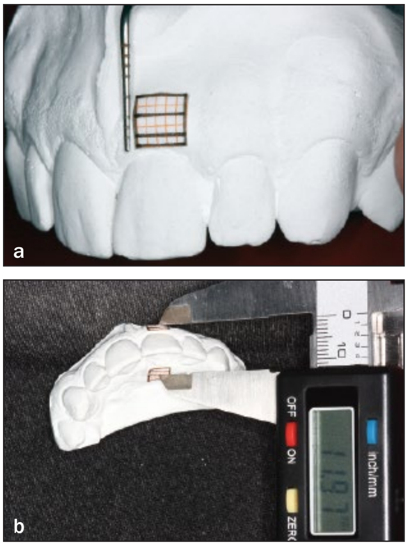



**Fig 15** *(Left)* Study casts made from alginate impressions taken at four different time points were marked at the 1-, 3-, and 5-mm levels from the free gingival margin both on the buccal and palatal sides.

**Fig 16** *(Below)* Distribution of the 80 study implants.

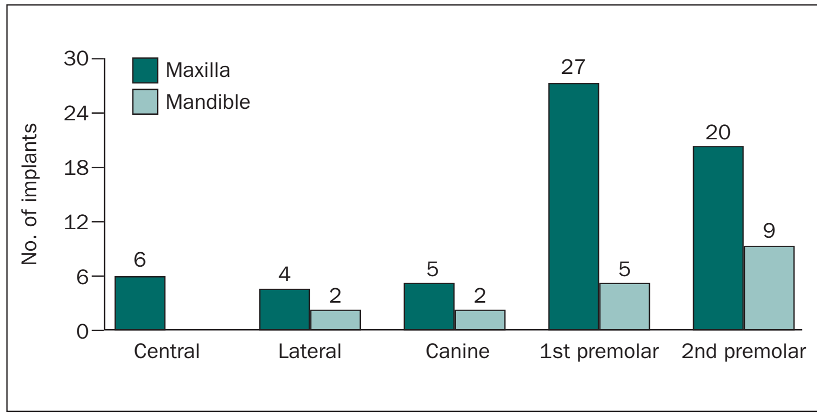



**Table 1 Mean Reduction (mm) in Horizontal Ridge Width for 13 Group 1 Implants That Received a Healing Abutment and No Grafting**

| Measure/difference | Estimate | SE | *P* value |
|---|---|---|---|
| **1 mm** | | | |
| 0–1 mo | 1.29 | 0.13 | .00 |
| 0–3 mo | 1.51 | 0.13 | – |
| 0–6 mo | 2.07 | 0.13 | – |
| **3 mm** | | | |
| 0–1 mo | 1.10 | 0.13 | .00 |
| 0–3 mo | 1.59 | 0.13 | – |
| 0–6 mo | 2.07 | 0.13 | – |
| **5 mm** | | | |
| 0–1 mo | 0.90 | 0.12 | .00 |
| 0–3 mo | 1.46 | 0.12 | – |
| 0–6 mo | 1.99 | 0.12 | – |

**Table 2 Mean Reduction (mm) in Horizontal Ridge Width for 13 Group 2 Implants That Received a Healing Abutment and Grafting**

| Measure/difference | Estimate | SE | *P* value |
|---|---|---|---|
| **1 mm** | | | |
| 0–1 mo | 0.96 | 0.13 | .00 |
| 0–3 mo | 0.90 | 0.13 | .00 |
| 0–6 mo | 0.82 | 0.13 | .00 |
| **3 mm** | | | |
| 0–1 mo | 0.82 | 0.13 | .00 |
| 0–3 mo | 0.87 | 0.13 | .00 |
| 0–6 mo | 0.90 | 0.13 | .00 |
| **5 mm** | | | |
| 0–1 mo | 0.29 | 0.12 | .08 |
| 0–3 mo | 0.36 | 0.12 | .01 |
| 0–6 mo | 0.43 | 0.12 | .00 |

**Table 3 Mean Reduction (mm) in Horizontal Ridge Width for 20 Group 3 Implants That Received a Provisional Restoration and No Grafting**

| Measure/difference | Estimate | SE | *P* value |
|---|---|---|---|
| **1 mm** | | | |
| 0–1 mo | 0.19 | 0.10 | .25 |
| 0–3 mo | 0.31 | 0.10 | .01 |
| 0–6 mo | 0.48 | 0.10 | .00 |
| **3 mm** | | | |
| 0–1 mo | 0.24 | 0.10 | .11 |
| 0–3 mo | 0.51 | 0.10 | .00 |
| 0–6 mo | 0.63 | 0.10 | .00 |
| **5 mm** | | | |
| 0–1 mo | 0.22 | 0.10 | .11 |
| 0–3 mo | 0.45 | 0.10 | .00 |
| 0–6 mo | 0.59 | 0.10 | .00 |

**Table 4 Mean Reduction (mm) in Horizontal Ridge Width for 34 Group 4 Implants That Received a Healing Abutment and Grafting**

| Measure/difference | Estimate | SE | *P* value |
|---|---|---|---|
| **1 mm** | | | |
| 0–1 mo | 0.13 | 0.08 | .35 |
| 0–3 mo | 0.26 | 0.08 | .01 |
| 0–6 mo | 0.27 | 0.08 | .00 |
| **3 mm** | | | |
| 0–1 mo | 0.12 | 0.08 | .44 |
| 0–3 mo | 0.24 | 0.08 | .02 |
| 0–6 mo | 0.30 | 0.08 | .00 |
| **5 mm** | | | |
| 0–1 mo | 0.15 | 0.07 | .18 |
| 0–3 mo | 0.26 | 0.07 | .00 |
| 0–6 mo | 0.34 | 0.07 | .00 |

| Table 5 Analysis of Variance *P* Values by Measure | | | |
|---|---|---|---|
| **Measure** | **Time** | **Group** | **Interaction** |
| 1 mm | .00 | .68 | .00 |
| 3 mm | .00 | .19 | .00 |
| 5 mm | .00 | .01 | .00 |

**Table 6 Post Hoc Means Difference by Measure (Significant Differences Only)**

| Measure/time | Difference | Estimated difference | *P* value |
|---|---|---|---|
| **1 mm** | | | |
| 0 mo | Healing abutment–provisional | 1.4 | .01 |
| 0 mo | Healing abutment– provisional and graft | 1.1 | .03 |
| **3 mm** | | | |
| 0 mo | Healing abutment– provisional | 1.7 | .01 |
| **5 mm** | | | |
| 0 mo | Healing abutment–provisional | 2.1 | 0 |
| 0 mo | Provisional– provisional and graft | –1.4 | .02 |
| 1 mo | Provisional– provisional and graft | –1.4 | .01 |
| 3 mo | Provisional– provisional and graft | –1.6 | .01 |
| 6 mo | Provisional– provisional and graft | –1.6 | 0 |

abutments. After 6 months, the mean horizontal ridge dimension had diminished by 2.07 ± 0.13 mm (*P* = .00) at a distance 1 mm from the free gingival margin, by 2.07 ± 0.13 mm (*P* = .00) at the 3-mm distance, and by 1.99 ± 0.12 mm (*P* =.00) at the 5-mm point.

Table 2 shows the mean horizontal dimensional reduction at the three levels 1, 3, and 6 months after placement of the group 2 implants, the healing abutments, and the graft material. After 6 months, the mean horizontal ridge dimension had shrunk by 0.82 ± 0.13 mm (*P* = .01) at a distance 1 mm from the free gingival margin, by 0.87 ± 0.13 mm (*P* = .00) at the 3-mm distance, and by 0.43 ± 0.12 mm (*P* = .72) at the 5-mm point.

Table 3 shows the mean horizontal dimensional reduction at the three levels 1, 3, and 6 months after placement of the group 3 implants and their provisional restorations. After 6 months, the mean horizontal ridge dimension had shrunk by 0.48 ± 0.10 mm (*P* = .00) at a distance 1 mm from the free gingival margin, by 0.63 ± 0.10 mm (*P* = .00) at the 3-mm distance, and by 0.59 ± 0.10 mm (*P* = .16) at the 5-mm point.

The group 4 implants exhibited the least amount of horizontal shrinkage. Table 4 shows the mean horizontal dimensional reduction at the three levels 1, 3, and 6 months after placement of those implants, their provisional restorations, and the graft material. After 6 months, the mean horizontal ridge dimension had shrunk by 0.27 ± 0.08 mm (*P* > .999) at a distance 1 mm from the free gingival margin, by 0.30 ± 0.08 mm (*P* = .99), and by 0.34 ± 0.07 mm (*P* = .00) at the 5-mm point. Notably, for this group, the horizontal ridge dimensions remained almost stable between the Time 2 and Time 3 measurement points.

## Statistical Analysis and Results

The analysis goals were to test whether different clinical treatments affect the measures behavior over time significantly, and which pairs of groups are statistically different at different times. The first research question has been verified performing a repeated measures ANOVA and evaluating the *P* value of the interaction between time and group (Table 5). The second one has been assessed by a post hoc analysis using the Tukey approach to compare pairwise mean differences (Table 6). The R Statistical Software (R Core Team 2015)[20] has been used for the analysis as well as the following R packages: lsmeans[21] and nlme[22]. Significance was assessed using the following type I error level: $\alpha$ = .05 (5%). A lower bound of the power of the experiment has been retrospectively estimated equal to $1-\beta$ = 96% using the GPower software (Faul et al, 2007)[23] and assuming an $\alpha$ = .05, a medium size effect f = 0.25, and a sample size for each experimental group equal to the minimum observed one.[13]

Table 5 shows *P* values of the time, group, and their interaction for the three outcomes. It has been observed that the interaction of group and time is always significant (*P* value always close to zero). Thus, some groups evolve differently than others as time passes.

Absolute values of 1, 3, and 5 mm by time and group are shown in Fig 17, while Table 6 shows estimated pairwise differences between group means by time, split by outcomes. Only pairwise differences with the *P* value below the significance threshold are shown. Pairwise differences are significant at Time 0 (*P* values between .01 and .03), except for 5 mm, where the differences between the "provisional" and "provisional and graft" groups were significant throughout the following periods (Table 6, *P* values .02, .01, .01, and 0, respectively, for time 0, 1, 3, and 6 months).

In a similar way, the differences between Time 0 and the other time frames have been estimated using post hoc analysis and, after being rearranged, are shown in Tables 1 to 4.

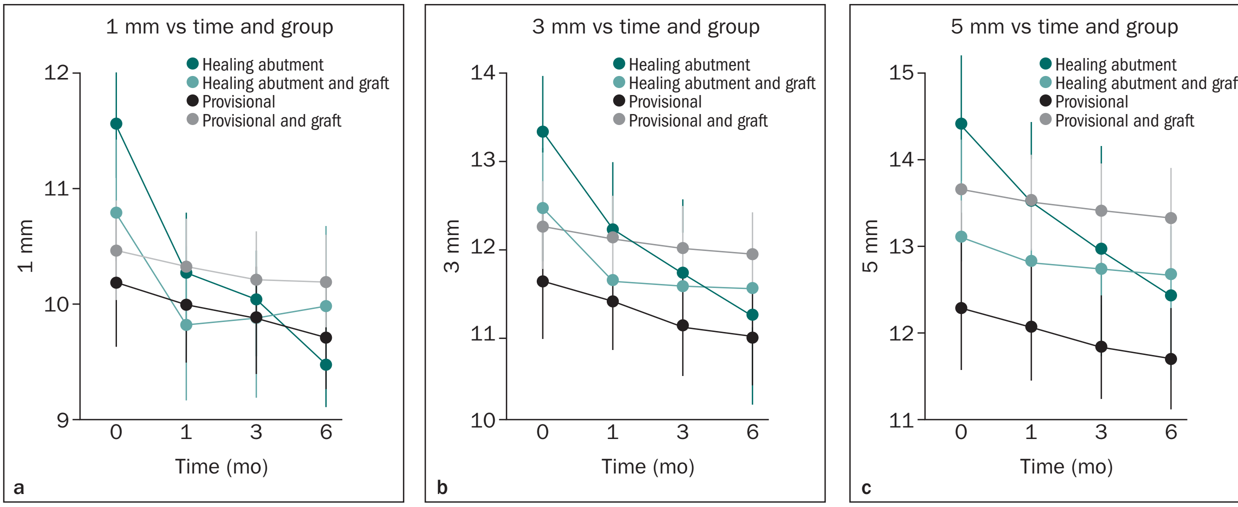



**Fig 17** Dimensional variation by time and groups.

## DISCUSSION

Implant placement into fresh extraction sockets with immediate provisionalization may help to maintain the hard and soft tissue architecture, shorten treatment time, and achieve good esthetic results.[15,24] Survival rates comparable to those of implants placed according to traditional staged surgical procedures can be obtained if proper primary stability of the implant is achieved and a load-free healing period is guaranteed.[13,25]

Nonetheless, although predictable results have been demonstrated for immediate extraction placement, many practitioners are cautious about placing implants immediately after extraction of teeth in the esthetic zone because of the bone remodeling that commonly occurs after tooth removal.[26] Both animal and human studies have demonstrated the occurrence of vertical and horizontal ridge resorption when implants are inserted in fresh extraction sockets. Resorption of the buccal plate tends to be more pronounced because of the nature of the bundle bone.[9,27,28] The inevitable bone changes that follow tooth extraction can be detrimental to both the buccal plate shape and volume.[29] Gingival recession also can occur, compromising the final esthetic outcome.[30]

Among the factors that play a role in postextraction dimensional tissue changes are flap elevation, grafting, and the shape of the provisional prosthesis. A number of studies have shown that flap-elevation procedures are associated with a significant reduction in the bone volume at extraction sites.[31,32] In a 2008 histologic dog study, Fickl et al furthermore demonstrated that placing implants with a flapless procedure resulted in a significantly lower reduction of the alveolar volume and had advantageous effects on the resorption.[33] Leaving the periosteal attachment intact appears to protect the underlying bone, reducing the amount of bone resorption.

While grafting of extraction sockets does not per se prevent alveolar bone remodeling after extraction, it does appear to minimize buccal bone collapse. Araújo et al in 2015 stated that the use of graft material in fresh extraction sockets cannot avoid the bone crest resorption but can significantly affect the volumetric reduction of the alveolar tissue.[34]

The role of the provisional prosthesis in supporting the soft tissue volume was first discussed almost 100 years ago.[35] In the 1930s, with the lack of grafting materials, more than one author proposed the use of an ovate pontic to support and maintain the soft tissue architecture in the pontic sites after tooth extraction.[36,37]

Although this is a different clinical scenario, it confirms the idea that the provisional plays a role in supporting and conditioning the soft tissue upon postextraction tissue healing.

More recently, Pozzi et al showed a way to condition the soft tissue immediately after extraction by optimizing the emergence profile of the provisional prosthesis.[38] In 2007, Steigmann et al described the technique to use the natural tooth as a provisional restoration to support the soft tissue with its natural contour.[39] In 2014, Tarnow et al, comparing different variables (eg, the healing abutment, graft, and provisional prosthesis) that may prevent postextraction dimensional changes following immediate extraction placement, demonstrated that a minimal amount of volumetric tissue reduction was found when both graft material and a provisional were inserted. They stressed the importance of the provisional prosthesis in maintaining the original volume and shape of the peri-implant tissue.[31]

In the present study, different combinations of three variables were analyzed. The ridge dimensions were measured over time at three tissue levels (1, 3, and 5 mm from the free gingival margins, buccal and lingual) in order to help clarify the precise role of the provisional restoration and the graft. In the most coronal part of the gingival margin (approximately 3 mm), the soft tissue is not supported by the alveolar bone, but rather, by the contour of the natural tooth. At 5 mm from the gingival margin, however, the underlying alveolar bone crest is responsible for maintaining the tissue profile.[2] It has been theorized that insertion of graft material after immediate extraction implant placement provides a solid scaffold on which blood clots can organize and creates spaces that facilitate tissue-volume maintenance. The emergence profile of the provisional restoration mechanically supports the soft tissue, preventing its collapse after tooth extraction.[2]

The results of the present study supported those assumptions. The group 1 implants, for which neither graft material nor provisional restorations were present, showed the greatest amount of horizontal volumetric tissue reduction. In group 2, where graft material was placed and a healing abutment was connected, minimal reduction in the horizontal dimension was noticed at the 5-mm level because of the presence of the graft, but significant horizontal reduction (approximately 1 mm) was found in the most coronal 3 mm because of the lack of mechanical support to the soft tissue from any provisional restoration.

In group 3, the provisional restoration evidently played a role in supporting the soft tissue; only 0.5 mm of reduction was found at the 3-mm gingival level, but more horizontal volume reduction occurred at the 5-mm level as compared with group 2 because graft material was not used. Finally, in group 4, the amount of volumetric tissue changes at all three reference points was less than 0.3 mm (virtually undetectable) because of the presence of both graft material to maintain the hard tissue volume and a provisional to support the soft tissue architecture. Although insertion of an implant in fresh extraction sockets does not prevent the typical alveolar bone remodeling that follows tooth extraction, the use of bone graft material and the insertion of an immediate provisional restoration can minimize the volumetric tissue changes.[32]

Whenever immediate implant provisionalization is under consideration, good primary stability is an important prerequisite.[40,41] It can be obtained by engaging apical and/or mesiodistal alveolar bone. The insertion torque value is one parameter of primary stability.[42] High insertion torque can minimize implant micromovement and optimize implant osseointegration.[43] Moreover, human studies have demonstrated that high insertion torque values do not interfere with implant osseointegration, but rather, ensure the reduction of implant micromovement and enhance implant healing.[39,44,45]

A flapless approach is always preferable.[31,32,46] Bone grafting with or without immediate screw-retained provisionalization can reduce vertical and horizontal bone resorption, especially for patients with thin scalloped gingival tissue, for whom bone resorption often causes excessive midfacial gingival recession.[33]

## CONCLUSIONS

Within the limitations of this study, it can be concluded that horizontal dimensional changes at single-tooth extraction sites in the esthetic zone after flapless immediate implant insertion can be minimized using immediate connection of a fixed provisional crown in combination with bone grafting in the facial area. This combination, when compared with the immediate connection of a healing abutment alone or in conjunction with the graft, showed the best results in terms of hard and soft tissue contour preservation. Using a flapless approach and supporting both the hard and soft tissue by immediately inserting a provisional restoration and graft material appears to compensate for the typical postextraction bone remodeling, enabling preservation of the tissue volume and enhancing the final esthetic results. Patients who need to replace a single tooth in the esthetic area can predictably be treated with immediate implant insertion and provisionalization that preserves their tissue volume and contours when the protocol employed in the present study is followed. More studies and larger samples are needed to further validate this conclusion.

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