Dimensional Variations in the Soft Tissue Profile After Removal of Implant-Supported Fixed Interim Restorations: A Pilot Clinical Study

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CLINICAL IMPLICATIONS

Accurate transfer of soft tissue dimensions after removal of implant-supported fixed interim restorations (ISFIRs) is of importance to minimize errors that can translate into uneven gingival plane profiles for the definitive restorations. Understanding the limitations of digital impression techniques may help prevent incorporation of such inaccuracies at the earliest stages of prosthetic implant therapy.

ISFIRs introduce progressive occlusal loading while simultaneously sculpting periimplant soft tissue profiles.[1–5] Adequately contoured implant restorations transition from the circumferential shape of the implant body to the corresponding cervical tooth anatomy.[6] Accurate transfer of the periimplant soft tissue emergence profile results in improved esthetic outcomes for the final restoration, defining the gingival margin level, papillae height, labial alveolar

Purpose: *To measure dimensional changes of the periimplant soft tissue profile after removal of a single implant fixed interim restorations using digital impression procedures.*

Materials and Methods: *Ten participants presenting with single implant-supported fixed interim restorations (ISFIRs) on the maxillary esthetic zone. A 2-step silicone impression was made of the maxillary arch with the ISFIRs. The experimental procedure was obtained by making digital impressions of the gingival contours immediately after ISFIR removal. The control procedure was formed by fabricating definitive casts from the conventional impression using the ISFIRs as a customized impression transfer and making digital impressions of these definitive casts. Both images of paired groups were digitally overlapped on the computer, and their profiles were measured at the coronal, midlevel gingiva in the buccolingual and mesiodistal width.*

Results: *Statistically significant differences between the ISFIR emergence profile width and the unsupported soft tissue profile width were observed at the midlevel gingiva in the buccolingual dimension (1.35 mm) and at the coronal (0.51 mm) and midlevel gingiva (1.29 mm) in the mesiodistal dimension.*

Conclusions: *A digital impression, as used in this pilot study, does not capture accurately the desired soft tissue dimensions immediately after removal of the ISFIR. (Implant Dent 2018;27:28–32)*

Key Words: digital impression, emergence profile impression, accurate transfer soft tissue

profile, and gingival color.[7–9] Because unsupported soft tissues are not dimensionally stable,[10] various transferring techniques of these periimplant soft tissue profiles have been described in the literature.[11–15] A recently published pilot study demonstrated that when the emergence profile of the ISFIR is impressed directly, it will yield the most accurate 3-dimensional replica of the targeted periimplant soft tissues.[16]

Since the early 1980's digital technology has been applied to restorative procedures, computer-assisted design and manufacturing (CAD/CAM) in combination with digital impression making has been changing the landscape of prosthetic dentistry.[17] Although the preparatory process, lack of both unpleasant taste, and gag reflex stimulation are all well received by patients, the overall time involved with digital impression

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acquisition has a negative perception according to Wismeijer et al.[17] Digital implant impressions facilitate the virtual assessment of restorative space, tissue dimensions, and the profile before laboratory manufacturing procedures begin. There is scarce knowledge related to the accuracy of digital impressions in implant dentistry.[18] The accuracy of digital impression has been questioned. Lee et al[19] state that milled models from digital impressions present a statistically significant difference regarding the vertical position of the implant, which happens to be more coronal when compared with the master model. Scan bodies (cylindrical scannable impression copings) replace the ISFIR during digital impression making. Periimplant soft tissue collapse leading to inaccurate transfer of the desired soft tissue profile has been associated with the use of these components.[20,21]

The purpose of this study was to measure dimensional changes of the periimplant soft tissue profile width after removal of single implant fixed interim restorations using digital impressions. The authors propose a hypothesis where there is a statistically significant difference between the emergence profile width of the ISFIR and the inner profile width of unsupported periimplant soft tissue.

MATERIALS AND METHODS

Participant Selection

Ten systemically healthy participants with no contraindications for dental therapy presenting with a maxillary single implant placed between first premolar and central incisor, ages ranging from 38 to 74 years, 6 women and 4 men, with no contraindications for dental therapy, were enrolled in this study. All participants consented to proceed with restorative procedures including the fabrication of customized impression and digital impression to facilitate the fabrication of the definitive implant-supported prosthesis. Written informed consent was obtained from all participants included in the study.

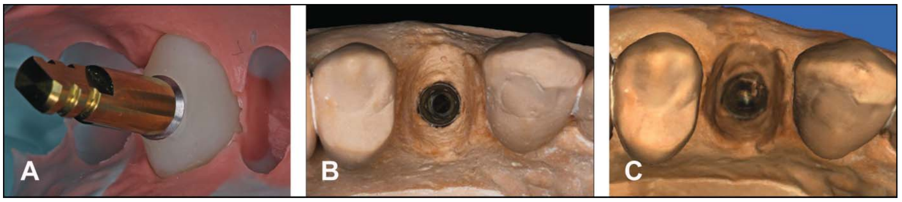

Fig. 1. Control group procedure. **A**, After obtaining a conventional intraoral impression, the ISFIR was removed and fixed to a corresponding implant analog and then placed inside the impression as a closed tray transfer simile. **B**, Stone master cast. **C**, Digitally scanned impression of the master cast.

In obtaining written informed consent and in conducting the study, the principles outlined in the Declaration of Helsinki, as revised in 2000.

Each participant had a screw-retained ISFIR, which had been fabricated at the time of implant placement. Individual endosteal implants (Tapered Internal Implant; BioHorizon Birmingham, AL) (internal conical connection, diameter between 4.6 mm/3.8 mm) had been placed immediately after tooth removal at approximately 3 mm apical to the zenith of the buccal gingival margin and had not had any complication during their healing period that ranged from 90 to 120 days. These 10 participants had a digital impression (experimental procedure) and a conventional impression (control procedure) made to accomplish the restorative phase of their implant therapy.

Control Procedure

A 2-staged definitive impression of the ISFIR was made using first the putty component of the polyvinyl siloxane impression material, followed by the light body (Exaflex; GC, Tokyo, Japan). After obtaining the impression, the ISFIR was removed and fixed to a corresponding implant analog. The ISFIR was placed inside the impression as a closed tray transfer simile (Fig. 1, A). A definitive cast was immediately poured with die stone type IV (Silky Rock; Whip Mix Co., Louisville, KY). The ISFIR was then removed from the obtained cast (Fig. 1, B). Finally, the definitive cast was digitally scanned with Cerec Omnicam; Sirona Dental System capturing the implant platform, emergence profile, and adjacent teeth (Fig. 1, C). The 3D model of the cast was saved in Cerec SW 4.4; Sirona Dental System, Bensheim, Germany.

Experimental Procedure

An intraoral digital impression of the implant and the circumferential soft tissue profile was performed immediately after removal of the ISFIR (Fig. 2). This captured image required the complete reproduction of the implant platform, soft tissue profile, and adjacent teeth. Total time elapsed between ISFIR removal and scanning completion did not exceed 10 seconds. The 3D intraoral model was saved within the same patient file of the control procedure using Cerec software.

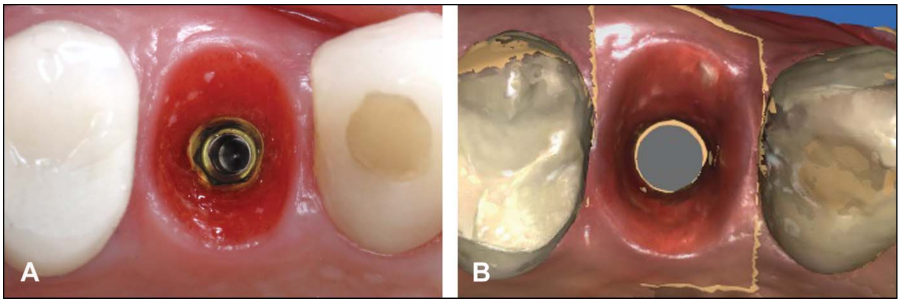

Fig. 2. Experimental group procedure. **A**, Implant socket after removal of ISFIR. **B**, An intraoral digital impression of the implant and the soft tissue profile was performed immediately after removal of the ISFIR.

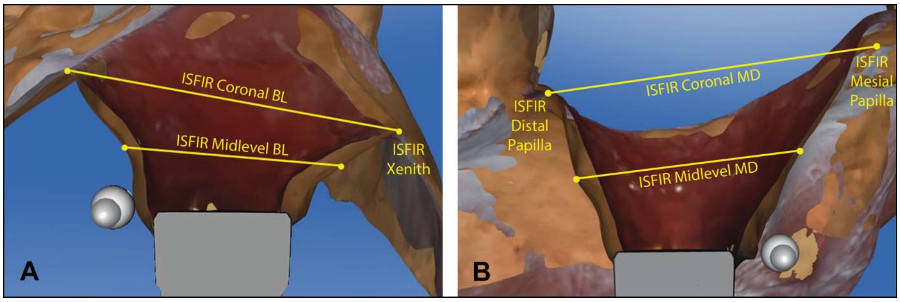

Fig. 3. Cross-sectional width measurement of ISFIR's emergence profile at the coronal gingiva and midlevel gingiva. **A**, BL view. **B**, MD view.

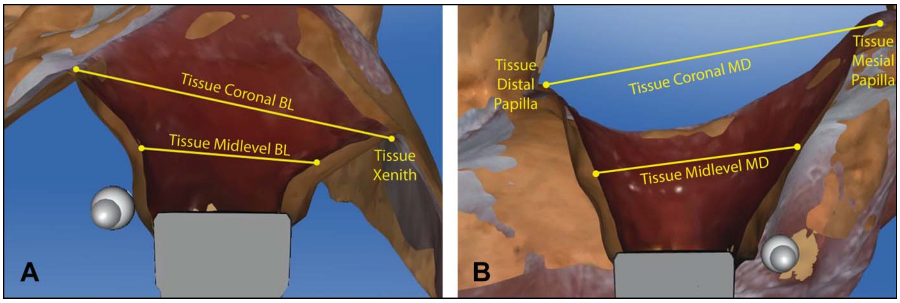

Fig. 4. Cross-sectional width measurement of the unsupported soft tissue profile at the coronal gingiva and midlevel gingiva. **A**, BL view. **B**, MD view.

Image Overlapping and Measurements

The definitive cast (representing the ISFIR's emergence profile) and intraoral (representing the soft tissue unsupported profile) 3D models of each participant were automatically overlapped by software, using the adjacent teeth as positional references. Placing the overlapped models at the maximum zoom scale, with the implant's main axis parallel to the view angle and rotated to a mesial view, the cut tool from the analyzing tool menu was turned on. The obtained image was a buccolingual (BL) cross section of the model at the center axis of the implant. Using the distance tool from the analyzing tool menu, BL linear width measurements were performed at the most coronal point of the gingival margin and at the middle (equidistant point between implant platform and gingival margin) of the emergence profile for both paired groups (Figs. 3 and 4, A). The zenith displacement between the 2 groups was also measured, considering the highest point of the buccal soft tissue displayed by the BL cross section. After all measures were recorded, the model was rotated to a buccal view of the implant, and the cut tool was used to obtain a mesiodistal (MD) cross section of the model at the center axis of the implant. MD linear width measurements were performed at the most coronal point of the papillae and at the middle of the profile for both paired groups (Figs. 3 and 4, B). Papillae height discrepancies between both groups were measured, considering the highest point of the mesial and distal soft tissue displayed by the MD cross section (Fig. 5).

Statistical Analysis

Each width recorded was considered a measurement unit. A paired *t* test was performed to compare the measured values within control (ISFIR's emergence profile) and experimental (unsupported soft tissue profile) groups. The significance value of this study was 0.05.

RESULTS

Emergence profiles of ten participants were included in this investigation, recording 8 linear measurements per participant (Table 1). The BL emergence profile width at the coronal gingiva level showed no statistically significant differences between experimental and control groups ($P = 0.147$). The BL emergence profile width at the midlevel gingiva showed statistically significant differences between experimental and control groups ($P < 0.001$). The MD emergence profile width at the coronal gingiva and midlevel gingiva showed statistically significant differences between experimental and control groups ($P = 0.002$ and $P = 0.001$, respectively). The positional

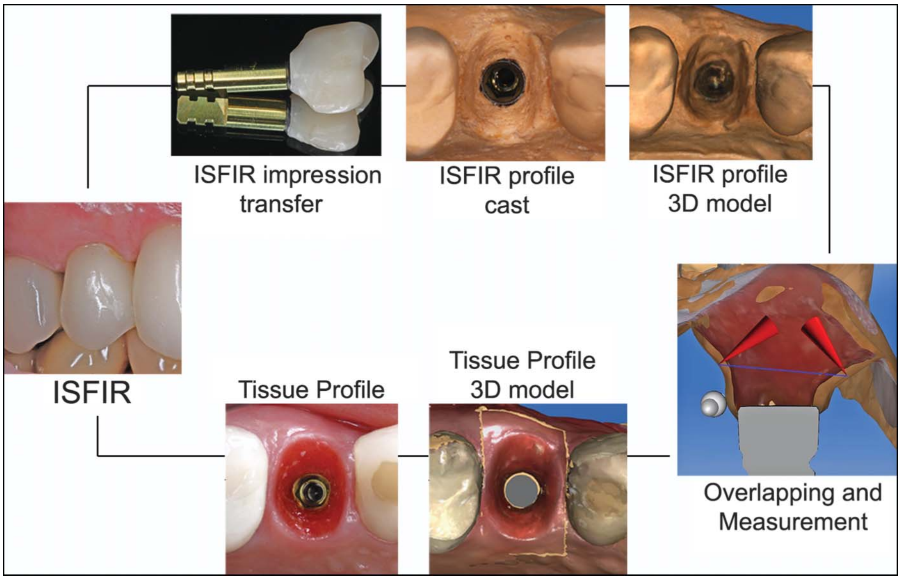

Fig. 5. Material and method workflow.

Table 1. Mean Emergence Profile Width in Millimeters (SD)

Parameter	Soft Tissue	ISFIR	*P*
Coronal gingiva			
BL	8.35 (0.96)	8.59 (0.96)	0.146
MD	7.07 (0.80)	7.58 (0.94)	0.002*
Midlevel gingiva			
BL	4.56 (0.78)	5.91 (0.85)	<0.001*
MD	4.58 (0.69)	5.87 (0.70)	0.001*

n = 10.
The BL emergence profile width at the coronal gingiva level showed no statistically significant differences between experimental and control groups. The BL emergence profile width at the midlevel gingiva showed statistically significant differences between experimental and control groups. The MD emergence profile width at the coronal gingiva and midlevel gingiva showed statistically significant differences between experimental and control groups.
*Statistically significant difference.

Table 2. Mean Positional Discrepancy of the Soft Tissue When Removing the ISFIR in Millimeters (SD)

Parameter	Discrepancy
Buccal zenith	0.14 (0.17)
Mesial papilla	0.50 (0.54)
Distal papilla	0.48 (0.48)

n = 10.

discrepancy (SD) of anatomical references when removing the ISFIR was also recorded (Table 2): buccal zenith 0.14 mm (0.17), mesial papilla 0.48 mm (0.47), and distal papilla 0.50 mm (0.54).

Discussion

The emergence profile of the implant-supported restoration derives a critical effect on periimplant tissue health, hygiene, and esthetics.[6] The fabrication of the subgingival contours of the definitive prosthesis should be guided by the existing tissue dimensions obtained during the provisionalization phase. Obtained results support the acceptance of the alternative hypothesis where there is a statistically significant difference between the emergence profile of the ISFIR and the inner profile of unsupported periimplant tissue. Without an accurate impression tool, the transference of the sculpted soft tissue will remain a challenge and could become guesswork at best.[7,8]

Immediate provisionalization allows for healing and maturation of tissues around the ISFIR and facilitates the sculpting of an ideal periimplant soft tissue profile.[14] Nevertheless, unsupported soft tissues are far from being dimensionally stable and still rely on the support provided by the ISFIR to maintain their contours. Once the interim restoration is removed, periimplant soft tissue collapses vertically and horizontally as a result of lacking physical support. Periimplant soft tissue presents less vascularity because of the absence of the periodontal ligament, and collagen fibers are not anchored intrinsically to titanium and are oriented parallel to the restorative surface.[9] The role played by the soft tissue biotype in soft tissue collapse and the degree of dimensional deformation of periimplant soft tissues has not been established. The nature of the orientation of connective tissue fibers (parallel to the implant surface) may contribute to the fast loss of stability of periimplant soft tissues.

For these reasons, it is suggested that the chosen impression technique ought to accurately capture the contours of the ISFIR. Although the literature in this field is sparse, a pilot study suggests that less soft tissue dimensional distortions were incorporated when obtaining a master cast by fabricating a customized impression coping using a direct technique to capture the contours of the ISFIR.[16]

Three-dimensional intraoral digital impressions are becoming more popular for the fabrication of implant-supported restorations. The difference in form between circular implant scan bodies and well-designed mucosal architecture with a provisional retained restoration does not permit a full digital workflow in the esthetic zone.[20] During scan body insertion, the periimplant soft tissue and the emergence profile collapse, causing misinterpretation of the soft tissue outline. Consequently, the undercontour generated during the digital impression could lead to a poor esthetic outcome. It has been proposed that digital implant impressions should evolve to capture periimplant tissue contours with personalized scan bodies.[20,21] This technique limits the reproduction of the soft tissues at the levels of the implant platform and its gingival contours (the profile of the entire submucosal portion cannot be captured).

In this study, dimensional changes of periimplant soft tissues registered on retrieval of ISFIRs for digital impression making happened at the midlevel gingiva in the BL dimension and at the coronal and midlevel gingiva thirds in the MD dimension, which coincides with results obtained when compared other soft tissue transferring techniques.[16] Obtained dimensional changes varied from 0.51 at coronal to 1.35 mm at the midlevel gingiva.

The scanning time of the periimplant soft tissue profile on ISFIR retrieval can determine the degree of soft tissue collapse. Faster digital impression times may render less soft tissue dimensional changes. In this study, no scanning procedures took longer than 10 seconds. Studies considering dimensional changes in soft tissue as a function of scanning time are required. This study had only 10 participants being evaluated. A larger sample would help validate the findings presented in this article. Study limitations such as the number of participants, scanning time standardization, and identification of the periimplant soft tissue biotype have been identified by the authors.

To obtain an accurate transfer of the periimplant soft tissue profile with an analog technique (conventional silicone technique), the impression coping can be customized indirectly by mirroring the subcervical anatomy of the ISFIR. If a digital impression is used, discrepancies need to be compensated by augmenting the dimensions of the restoration according to the measurements described in this study (0.5 mm MD width at the coronal gingiva level and 1.3 mm at the BL width and at the MD midlevel gingiva). Lee[22] proposes to scan the cervical portion of the ISFIR, so this can be duplicated accurately in the definitive restoration. Unfortunately, not all software applications allow for execution of this protocol, and more studies are needed to verify if this technique does not alter dimensional changes of the emergence profile of the ISFIR and the definitive restoration. To minimize inaccuracies, the authors recommend making an impression of the ISFIR (as described during the control procedure preparation). The obtained definitive cast is then scanned and used as a digital reference in software to aid in the design of the emergence profile of the definitive restoration. Another alternative to accurately transfer emergence profiles into the definitive restoration is to fabricate the ISFIR with CAD-CAM.[23] In this way, the ISFIR contour will be recorded in software, and its 3D file can later be used by modifying the occlusal surface, interproximal contacts, and material for the definitive restoration.

CONCLUSIONS

Within the limitations of this study, results suggest that statistically significant differences between the ISFIR emergence profile width and the unsupported soft tissue profile width were observed at the midlevel gingiva in the BL dimension (1.35 mm) and at the coronal (0.51 mm) and midlevel gingiva (1.29 mm) in the MD dimension. A digital impression, as used in this pilot study, does not capture accurately the desired soft tissue dimensions immediately after removal of the ISFIR.

DISCLOSURE

The authors claim to have no financial interest, either directly or indirectly, in the products or information listed in the article.

APPROVAL

Institutional review board approval is not available. The authors did acquire appropriate consent forms from individuals involved in this project, and care was provided following universal guidelines as stipulated by the Declaration of Helsinki as outlined in the article.

ROLES/CONTRIBUTIONS BY AUTHORS

J. C. Duran: Principal author. F. Aguirre: Secondary author and digital image editor. R. Pino: Secondary author. D. Velásquez: Secondary author and principal investigator of preceding work (Ref. 16). All authors contributed to the design, execution, data analysis, and composition of the manuscript.

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