Comparing Dual-zone Immediate Implant Placement and Socket-shield Technique for Ridge Width Changes in Maxilla: a Prospective Cohort Study

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Research Article

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Abstract

Background: The socket-shield technique still requires more scientific based evidence to be recommended as everyday clinical practice, the aim of this prospective cohort study was to assess the facial-palatal ridge dimensional changes that occurred after a minimum of 8 months following flapless dual-zone (DZ) immediate implant placement and socket-shield (SS) immediate placement in the maxilla.

Methods: A total of 19 patients who received 20 implants were included with 10 implants (MegaGen AnyRidge) were placed for each treatment, DZ and SS. Cast models were made at least 8 months after implant placement to assess the dimensional ridge changes by measuring the facial palatal ridge width on implant sites (T) at six designated points starting from gingival margin (0, 1, 2, 3, 5 and 7) and comparing it with the corresponding measurement on contralateral tooth site (C).

Results: All 20 placed implants demonstrated successful osseointegration and survived 9-24 months following implantation (survival rate 100%). Two out of ten cases of SS group presented with minor manageable complications of external shield exposure. DZ group showed an average facial-palatal reduction of nearly 0.3 mm; however, there were no significant differences between T and C (P =.47), while SS group revealed a mean gain in ridge contour of approximately 0.2 mm with also no significant differences existed between T and C (P = .64) in the 8-months follow-up. When comparing between the two treatments, there were significant differences in ridge width changes (P < .05), indicating better preservation of the ridge contour at 8-months for SS treatment.

Conclusion: The socket shield immediate implant placement produced better preservation of the ridge contour at 8-months post-extraction; however, the dual-zone technique yielded non clinically significant reduction in the ridge contour at the same follow-up.

Background

After tooth extraction, alveolar ridge resorption vertically and horizontally will certainly occur [1, 2] mainly on the buccal side [1]. This is highly expected because once the tooth is extracted, it loses one of the main vascular supply to the facial plate which is the periodontal ligament [3]. In addition, the facial plate thickness in anterior maxilla has been reported to be 1 mm or less for nearly ninety percent of patients [4] that makes it more prone to surgical trauma and resorption [3]. Further, this 1-mm facial plate is composed mainly of cortical bone without any vascular supply from endosseous marrow [3]. This ridge resorption will have a negative sequel on implant position and on emergence profile of implant restoration [5] leading to aesthetic and biological complications, mainly in the maxillary anterior region. Consequently, every effort has been made to preserve or limit the physiological ridge shrinkage that occurs following tooth extraction, including socket preservation techniques [6, 7] and bone augmentation using different bone materials and different membranes [8, 9]. When accompanied with immediate implant placements, numerous recommendations and techniques have also been introduced for the same purpose of preserving the peri-implant hard and soft tissues. These include atraumatic tooth

extraction, meticulous case selection [10], flapless implant placement [11], ideal 3-D implant positioning [11], filling the jumping gap with bone substitute and up to gingival margin level (dual-zone) [12], connective tissue grafting at time of immediate implantation [13], immediate provisionlaization [14], and the use of implant with platform switching design [15]. However, none of these procedures could prevent the physiological bone remodeling that occurs post-extraction since its main causes of periodontal ligament loss and the thin buccal bundle bone are still existing [16, 17].

As a result, this has led to the rethinking of a previously introduced technique of root submergence which was firstly used in completely edentulous ridges to maintain the denture supporting area [18]. Then, this technique was utilized to preserve the alveolar ridges under pontics of fixed partial denture [19]. Based on the same concept of maintaining the periodontium of periodontal ligament, cementum and bundle bone, Huzler and colleagues [20] in 2010 introduced the “socket shield (SS) technique”. This technique involves maintaining the buccal segment of a root that is intended to be extracted and immediately replaced with an implant by decoronating the tooth, sectioning the root mesiodistally, then removing the palatal segment with the apex while maintaining the buccal segment. The implant is then placed palatal to the shield [20].

Two systematic reviews [21, 22], several case series [15, 23–26], many case reports [27–37], two technical reports [38, 39], two animal randomized controlled trials [40, 41], and two human randomized clinical studies [42, 43] were conducted on socket shield technique, with all showing promising outcomes.

Bramanti et al. [42] in their RCT compared socket shield immediate implant technique with conventional immediate implants. They reported 100% of implant survival rate without any complications up to three years follow up for both groups; however, the socket shield technique revealed better marginal bone levels and better pink esthetic scores [42]. The other RCT [43] which also compared between the same previously mentioned two groups demonstrated 100% implant survival rate without any complications up to two years follow up for both groups; however, socket shield technique resulted in less midfacial mucosal recession and less dimensional shrinkage of the buccal plate [43].

The most recent systematic review [22] concluded that in spite of the increased reported survival rates of implants placed with SS technique with only 6.96% of implant failures and complications demonstrated in clinical studies, this technique still requires more scientific based evidence to be recommended as everyday clinical practice. Thus, the aim of this prospective cohort study (PCS) was to compare the facial-palatal dimensional ridge changes that occurred after a minimum of eight months following flapless dual-zone (DZ) immediate implant placement with those occurring following socket-shield (SS) immediate placement in the maxilla. Also, this study aimed to report the incidence of any complications in the 8 months follow-up.

The primary outcome was the dimensional facial-palatal ridge changes that occurred after 8 months following immediate implant placement with the two techniques, and the secondary outcome was the incidence of any biological or biomechanical complications in the 8 months follow-up. Additionally, the influence of probable confounders like tooth type, gingival biotype, and the buccal plate thickness on the

dimensional facial-palatal ridge changes was also evaluated. The null hypothesis of this PCS was that there were no differences in the facial-palatal dimensional changes following 8 months post-extraction between the DZ immediate implant placement and SS immediate implant placement in the maxilla against the alternative hypothesis of a difference.

Methods

This single-center prospective cohort clinical study was conducted between June 2019 and June 2020 and included participants that were scheduled at Faculty of Dentistry, Arab American University, Palestinian Territory. The study was approved by the Arab American University scientific research council (SRC-17/18 – 10) and performed according to the ethical principles of the Declaration of Helsinki of 1975, as revisited in 2013.

For patients' selection, the inclusion criteria were any patient requiring at least one single immediate post-extractive implant in the maxilla from right second premolar to left second premolar for a non-mobile tooth, between two natural teeth, with existing contralateral tooth, being at least 20 years old, and able to sign an informed consent form. The exclusion criteria were general contraindications to implant surgery, radiotherapy in the head or neck area, chemotherapy for malignancy in the previous 5 years, uncontrolled diabetes, severe psychiatric disease, patients taking or had taken intravenous bisphosphonates, smoker of more than 9 cigarettes a day, pregnant or lactating women, severe parafunctional activity, acute infection or fistula in the site planned for implant insertion, vertical root fracture including the facial root or horizontal fracture apical to facial bone crest, mobility of grade two or more, moderate or severe periodontitis with more than three millimeters attachment loss, extensive apical lesion, ankylosed tooth, class II or III extraction sockets, and not attending the follow up appointments.

A sum of 40 patients were assessed, of whom 21 were excluded because they did not meet the inclusion criteria (Fig. 1). A total of 19 patients who received 20 implants were included. Selected patients received thorough explanations about the provided treatment and signed a written informed consent in which all treatment risks were explained prior to being enrolled in the study. The 20 implant sites were distributed between the two groups by attempting the socket shield with all the firstly enrolled cases until ten SS were done and any time the buccal shield got mobile, it was removed, and the case was shifted to DZ technique. The remaining cases were done with DZ technique. Therefore, ten implants were placed for each treatment, DZ and SS.

All the surgical and prosthetic procedures were performed by one experienced dentist (R.S.). Patients were followed for at least 8 months after implant placement, and the patients, the outcome assessor (F.M.) who executed the measurements, and the biostatistician were blinded.

Treatment procedures

Scaling and oral hygiene instructions were given for each patient two weeks before the surgery. Cone beam computed tomography (CBCT) was ordered for each patient to evaluate the site for the presence of

intact bone plates, if there is any pathology, and to assess the sagittal position of the root. All Patients received a single dose of prophylactic antibiotic 1 hour prior to the intervention (2 g of amoxicillin or 600 mg of clindamycin, if allergic to penicillin). Also, patients rinsed with chlorhexidine mouthwash 0.2% for 1 minute prior to the intervention.

Dual-zone immediate implant placement (DZ)

After the administration of local anesthesia, intrasulcular incision was made around the tooth or retained root to severe the supracrertatal fibers. The tooth was carefully luxated using periotomes and removed with forceps. Then, thorough debridement, curettage, and rinsing with sterile saline were made for the extraction socket, and the socket walls were checked with round ended probe for the presence of any fenestration or dehiscence defects. The case was included in the study if it had intact socket walls or just a small fenestration on the facial wall with intact marginal bone. The osteotomies were then prepared according to the manufacturer's instructions of the implant system (MegaGen AnyRidge, MegaGen Implant Co., Ltd., South Korea) and the implants were placed with handpiece toward the palatal wall up to 4 mm apical to mid-buccal gingival margin. Periapical radiographs were made to verify the position and angulation of the implants. Insertion torque (IT) and ISQ values (MegaISQ; MegaGen Implant Co., Ltd) were registered for each implant so any implant with IT $\geq$ 25N/cm and ISQ $\geq$ 65 was attached with S-shaped customized healing abutment, and any implant with less than these readings was decided for submerged healing. For both situations, granules of FDBA (Mineross, Biohorizons IPH, Birmingham, AZ, USA) were loosely packed into jumping gap regardless of its size and up to gingival margin (dual-zone technique). For implants selected for submerged healing, no primary closure was tried; instead, collagen sponge was placed on top of bone granules and stabilized with 5/0 polyamide nylon horizontal mattress and interrupted sutures (Filapeau, PETERS, France). For provisionalization, a resin-bonded bridge was stabilized to adjacent teeth. Post-surgery, the patients were asked to take antibiotics (amoxicillin 500 mg three times daily for 7 days), chlorhexidine gluconate 0.2% oral rinse 2 times daily for two weeks, and nonsteroidal anti-inflammatory drugs (ibuprofen 400 mg four times daily for 3 days). Patients were also instructed to avoid brushing the area for 2 weeks. Postsurgical evaluation was made at 1, 3, and 6 weeks to verify if there was any complication or infection. Sutures were removed during the 2-week postoperative visits.

Socket-shield immediate implant placement (SS)

After local anesthesia administration, the involved tooth was decoronated up to gingival margin with high-speed diamond chamfer bur. Then, the root canal was widened with successively increasing diameter Gates Glidden burs up to apical region to remove all canal contents verifying the correct length by periapical radiographs. To section the root mesiodistally, a long shank high-speed root resection bur (Komet Dental, Germany) was inserted to the same path created by Gates Glidden until the root was sectioned completely. If possible, the apical portion was aimed to be removed with the palatal portion from the first cut (Fig. 2). A small periotome was used to luxate the palatal section toward the space created by sectioning while maintaining finger support on buccal shield to verify if there is any movement during luxating the palatal segment. If apical portion was not removed with the palatal portion, it was

removed by inserting long shank high-speed bur. Thorough debridement, curettage, and rinsing with sterile saline were made to remove any residues of infection. To prepare the coronal portion of the shield, a micro-facial flap was raised to ensure cutting the buccal shield up to bone crest without traumatizing the gingiva, then a bevel was made on the coronal 2 mm portion of the shield internally with high-speed round diamond bur. This bevel was to create more prosthetic space while reducing the risk of shield exposure. A minimum thickness of 1.5 mm and a length of 6 mm were aimed. All procedures were conducted with magnification and high illumination. If there was any fenestration, it was managed by raising a semilunar flap in the apical area gaining access to the defect to ensure complete removal of infected tissue. After assessing the stability of the shield, implant osteotomy was made in the same manner as in DZ with trying to place an implant without touching the shield. Implant diameter (AnyRidge MegaGen, MegaGen Implant Co., Ltd., South Korea) was selected with trying to not contact the shield at the same time be appropriate for the replaced tooth (Fig. 3). The fenestrations when encountered, were grafted using guided bone generation with saline prehydrated FDBA (Mineross, Biohorizons IPH, Birmingham, AZ, USA) and collagen membrane (Mem-Lok RCM, Biohorizons IPH, Birmingham, AZ, USA), then primary closure was achieved with 5/0 polyamide nylon simple interrupted suture (Filapeau, PETERS, France). Granules of FDBA (Mineross, Biohorizons IPH, Birmingham, AZ, USA) were loosely packed into jumping distance regardless of its size and up to gingival margin. All subsequent steps were made the same as with DZ group. The protocol that was followed for performing SS technique in the present study was according to the most recent proposed guidelines [23, 39].

After approximately 4 months, all patients were asked to come to start with the prosthetic part. For non-submerged implants, the customized healing abutment was removed and ISQ was assessed to assess if the implant was ready for definitive prosthesis. If ISQ was ≥ 70, the definitive prosthesis impression was made. Regarding the submerged implants, uncovery was made with punch technique without any soft tissue enhancement, and ISQ was also assessed. All implants were ready for loading. To shape the soft tissue, customized healing abutment was attached to the implant for about four weeks before making the final impression. Pick-up implant-level impression copings were joined to the implants with flowable composite injected into the sulcus to transfer the soft tissue emergence profile to the soft tissue cast, then impression was made with putty soft/light body addition silicone material (Elite HD+, Zhermack SpA, Italy). Subsequently, screw-retained zirconia or metal-ceramic crowns were joined to the implants and the screw was torqued to 35 N/Cm using a calibrated torque wrench (MegaGen Implant Co., Ltd., South Korea). The access holes were sealed with Teflon tape and flowable bulk fill composite (Palfique Bulk Flow, Tokuyama Dental Corporation, Japan). Periapical radiograph was taken immediately after crown delivery as post prosthetic baseline.

Cast analysis

Maintenance and follow-up appointments were scheduled every three months where an impression was made with putty soft/light body addition silicone material (Elite HD+, Zhermack SpA, Italy) at least eight months after implant placement to assess the dimensional ridge changes that occurred post-implantation according to the method described by Tarnow et al. [3]. Measurements were made on type 3

gypsum (Marmodent, Siladent, Germany) casts with electronic digital caliper of 0.01 mm resolution (Salvin Dental Specialties, USA) on both the implant site (test) and the contralateral tooth site (control) at six designated points starting from free gingival margin toward apical area (0, 1, 2, 3, 5 and 7 mm). All measurements were repeated three times at each point by a trained blinded assessor (F.M.), then the means of the distances were recorded for each point (Figs. 4, 5).

Sample size calculation

Sample size was calculated using an online calculator (http://riskcalc.org:3838/samplesize/) [44], considering Type I error rate, α = 0.05, power = 90 % (β = 0.1), ratio of case to control, k = 1, mean (μ) DZ = 0.6, mean (μ) SS = 0.1 based on previous studies [3, 24], and expected population standard deviation, SD = 0.3 [24], the result was 16 for total sample size with 8 for each group. Considering the possibility of drop out, ten for each group was selected.

Statistical analysis

Data were analyzed statistically using the Statistical Package for Social Sciences (SPSS), version 22.0. Means and standard deviation (mean ± SD) were used to describe continuous data, and percentage of cases were used to present categorical data. Data were examined for normality using the Kolmogorov-Smirnov test. For normally distributed data, the differences in means between T and C in the same group or (T-C) between groups were evaluated with Independent Samples t Test, while Mann–Whitney U test was performed for non-normally distributed data. The level of statistical significance was considered at $P < .05$.

Results

This study encompassed 19 patients, four men and 15 women, aged 20 to 62 years, mean 35.70 ± 11.91 years. Twenty immediate implants were placed in 19 patients with one implant for each patient except one patient had two implants. The characteristics of the enrolled cases, tooth type, causes of extraction, implant dimensions, healing pattern, and the definitive restoration type are demonstrated for both groups in Table 1.

Table 1
The characteristics of the enrolled cases, implant dimensions, definitive restorations, and complications.

	SS (n = 10)	DZ (n = 10)	Total (n = 20)
Age (years)			
Mean ± SD	41.00 ± 12.00	30.40 ± 9.64	35.70 ± 11.91
Range	25–62	20–52	20–62
Gender			
Male, n (%)	2 (20)	2 (20)	4(20)
Female, n (%)	8 (80)	8 (80)	16 (80)
Healing pattern			
(S) Submerged, n (%)	5 (50)	3 (30)	8 (40)
(NS) Non-submerged, n (%)	5 (50)	7 (70)	12 (60)
Tooth type			
Central incisor, n (%)	3 (30)	0 (0)	3 (15)
Lateral incisor, n (%)	3 (30)	3 (30)	6 (30)
Canine, n (%)	2 (20)	1 (10)	3 (15)
Premolar, n (%)	2 (20)	6 (60)	8 (40)
Buccal plate thickness (mm)			
< 1, n (%)	4 (40)	6 (60)	10 (50)
≥ 1, n (%)	6 (60)	4 (40)	10 (50)
Gingival biotype			
Thick, n (%)	9 (90)	8 (80)	17 (85)
Thin, n (%)	1 (10)	2 (20)	3 (15)
Implant length (mm)			
13.0, n (%)	1 (10)	6 (60)	7 (35)
15.0, n (%)	9 (90)	4 (40)	13 (65)
Implant diameter (mm), n (%)	10 (100)	10 (100)	20 (100)
Extraction cause			
Extensive caries, n (%)	3 (30)	6 (60)	9 (45)

	SS (n = 10)	DZ (n = 10)	Total (n = 20)
Lack of ferrule, n (%)	5 (50)	3 (30)	8 (40)
Failed restorative treatment, n (%)	2 (20)	1 (10)	3 (15)
Smoking status			
Smokers*, n (%)	1 (10)	0 (0)	1 (5)
Non-smokers, n (%)	9 (90)	10 (100)	19 (95)
Apical fenestration managed with GBR, n (%)	2 (20)	0 (0)	2 (10)
Crown			
Zircon screw-retained, n (%)	10 (100)	8 (80)	18 (90)
Metal-ceramic screw-retained, n (%)	0 (0)	2 (20)	2 (10)
Complications, n (%)	2 (external shield exposure) (20)	0 (0)	2 (10)
SS: Socket shield technique DZ: Dual-zone technique GBR: Guided bone regeneration *Less than 10 cigarettes per day			

All patients presented for follow-up appointments without any loss. Uneventful healing without any postoperative complications went for all the ten implants in DZ group and for 8 implants in SS group, with an external shield exposure encountered for 2 implants at one month follow-up (20% complication rate). The two external shield exposures where the coronal portion of the shield perforated the soft tissue were managed by just reducing the exposed part with high-speed diamond bur and both healed well with soft tissue coverage. More dimensional ridge shrinkage occurred for these two cases (0.6, 0.7) but without soft tissue recession or esthetic compromise. The patients were satisfied with the esthetic result and refused any connective tissue grafting. All 20 placed implants demonstrated successful osseointegration with ISQ values in the 70’s at 4 months post-implantation and survived 9–24 months following implantation (survival rate 100%).

Twenty type 3 gypsum casts that were made from addition silicone after at least 8 months from implant insertion and 4 months from crown delivery were evaluated for the facial-palatal ridge dimensions at implant site (test) and contralateral tooth site (control) for both treatments (DZ and SS) and at varying locations from free gingival margin (0,1,2,3,5,7 mm). This was to assess the dimensional facial-palatal

ridge changes that occurred following immediate implant placement with the two treatments (DZ and SS). The results demonstrated that DZ group when averaged over all reference points showed a facial-palatal reduction of nearly 0.3 mm; however, there were no significant differences between T and C (*P* = .47), while SS group revealed a mean gain in ridge contour of approximately 0.2 mm with also no significant difference existed between T and C (*P* = .64) in the 8-months follow-up (Table 2, Figs. 6,7).

Table 2
Comparison of facial-palatal ridge width between T and C at different points (mean ± SD).

Points	Site	Group (SS)	*P* value*	Group (DZ)	*P* value*
Point 0	T	8.11 ± 1.38	0.95†	8.36 ± 1.43	0.35‡
	C	8.07 ± 1.23		8.78 ± 1.36	
Point 1	T	9.28 ± 1.42	0.97†	9.56 ± 1.33	0.32†
	C	9.31 ± 1.42		10.14 ± 1.22	
Point 2	T	10.14 ± 1.32	0.53‡	10.34 ± 1.48	0.38†
	C	9.95 ± 1.42		10.88 ± 1.20	
Point 3	T	10.81 ± 1.31	0.39‡	11.10 ± 1.38	0.44†
	C	10.43 ± 1.43		11.55 ± 1.14	
Point 5	T	11.68 ± 1.50	0.82†	12.60 ± 1.22	0.89†
	C	11.54 ± 1.46		12.53 ± 0.97	
Point 7	T	12.52 ± 1.68	0.68†	13.64 ± 1.39	0.60†
	C	12.22 ± 1.53		13.35 ± 1.01	
All points	T	10.42 ± 2.02	0.64†	10.93 ± 2.22	0.47†
	C	10.25 ± 1.94		11.20 ± 1.88	

* Intra-group differences

‡ Statistical analysis by Mann–Whitney U test

† Statistical analysis by Independent Sample T-test

T: implant site

C: contralateral tooth site

SS: socket-shield technique

DZ: dual-zone technique

When comparing between the two groups, there were significant differences in ridge contour changes (T-C) between the two groups when averaged over all distances from gingival margin ($P = .01$), suggesting better preservation of the ridge contour at 8-months for SS treatment. The null hypothesis that there were no differences in the facial-palatal dimensional changes following 8 months post-extraction between the DZ immediate implant placement and SS immediate placement could be rejected ($P < .05$).

Regarding the dimensional changes of the ridge contour in relation to the distance from gingival margin, the pattern of change was not consistent across the groups and revealed a high variation between the patients. The most reduction in the ridge contour of about 0.6 mm was shown at point 1 mm in DZ group (Fig. 8).

No effect was found for gingival biotype, buccal plate thickness, or tooth site (anterior vs. premolar) on the facial-palatal ridge changes. ($P > .05$).

Presentation of two treated cases

Presentation of an SS case (Fig. 9) and DZ case (Fig. 10). The SS case replacing maxillary right central incisor revealed superb preservation of the ridge contour with optimum functional and esthetic outcomes. The DZ case replacing maxillary left first premolar also revealed excellent functional and esthetic results but with some collapse of the ridge bucco-palatally.

Discussion

This prospective cohort clinical study aimed to assess the horizontal ridge changes that occurred after a minimum of eight months following flapless immediate implant placement with dual-zone technique and immediate placement with socket-shield technique in the maxilla, and to report the incidence of any biological or biomechanical complications in the 8 months follow-up. Therefore, single-tooth implants were inserted for patients requesting replacement of their hopeless teeth in the maxillary esthetic zone with considering the contralateral natural tooth as a control. The result of this study showed that SS produced a better preservation of the facial-palatal ridge contour following 8 months post- implantation compared with DZ technique.

Immediate implant placement survival rates are comparable to those of delayed implant placement while reducing the number of surgical procedures and the treatment time [45–47]. However, immediate placement presents with some shortcomings, including peri-implant mucosal recession, unpredictable esthetic results [11, 48], and alveolar ridge resorption and collapse [49]. A clinical study revealed that at least 1.9 mm horizontal collapse of the ridge occurred facially and 0.9 occurred palatally/ lingually after 4 months of immediate implant placement with flap elevation and without any bone or soft tissue augmentation [50].

Hence, several techniques have been proposed to reduce the collapse of the ridge post-implantation. Araújo et al. [51] demonstrated that placement of biomaterial in the gap between the implant and the

extraction socket walls altered the process of bone healing and reduced the amount of ridge collapse. Grunder [13] in a clinical study compared the horizontal dimensional shrinkage that occurred at 6 months post-implantation between flapless immediate placement with just healing abutment and no bone grafting and immediate placement with only connective tissue grafting. The results revealed an average collapse of 1.1 mm of the ridge facio-palatally in the nongrafted group, while a slight increase of 0.34 mm in the connective tissue-grafted group [13]. Another retrospective cross-sectional clinical cohort study showed that flapless dual-zone immediate implant placement either with prefabricated healing abutment or with provisional restoration yielded just an average of 0.4 mm of horizontal dimensional shrinkage at 12 months post-implantation [3]. While flapless immediate placement with no bone grafting in the facial gap either with or without provisional restoration resulted in approximately 1 mm facial-palatal reduction at 12 months post-implantation [3].

Immediate implant placement with socket-shield technique that involves maintaining the buccal segment of a root and immediately placing the implant palatal to the shield aims to prevent or minimize the post-extraction resorption of the alveolar bone [20]. In spite of no comparable group of the conventional technique, a retrospective case series study evaluated the facial-palatal dimensional changes after 5 years of ten SS immediate implant placement in the maxilla and revealed an average loss of 0.37 mm facially, suggesting that this technique could effectively preserve the peri-implant tissue contours [15]. Another prospective cohort study showed that the average collapse that occurred facially after 3 months from SS immediate implant placement with provisional restoration was 0.07 mm [24]. A recent randomized controlled clinal trial [43] compared conventional flapless immediate implant placement and socket shield technique for buccal plate width at 6 months post-extraction. They reported that SS group had significantly higher values of buccal plate width, indicating better preservation of ridge contour [43].

Although a direct comparison with these studies is not feasible due to different measurement techniques and due to different follow-up periods, the results of the present study are in agreement with the findings of those studies. It showed that SS technique produced a statistically significant superior maintenance of the ridge width at 8-months follow up compared with DZ technique ($P = .013$). When averaged over all reference points at 8-months follow-up, SS group revealed a mean gain of ridge contour of 0.17 mm, while DZ showed a mean facial-palatal reduction of 0.27 mm. The slight volume increase with SS group might be due to unavoidable measurement error rather than an actual gain. Why SS technique produced a statistically significant superior maintenance of the ridge width is explained by the fact that maintenance of the facial shield periodontal ligament and the facial bundle bone could minimize the physiological bone remodeling that occurs post-extraction [16, 17].

The clinically insignificant 0.27 mm mean facial-palatal reduction reported for DZ group is in accordance with the clinical retrospective study of Tarnow et al. [3] who demonstrated that flapless dual-zone immediate implant placement yielded an average of 0.4 mm of horizontal dimensional shrinkage at 12 months post-implantation. This result was justified by the supporting function of the bone graft particles that were placed in the labial gap and also in the tissue zone coronal to the implant-abutment junction [12].

With respect to implant survival rate, both techniques yielded 100% survival rate, and the socket shield in association with immediate implant placement did not disturb the implant osteointegration clinically. This finding is with agreement of other studies that assessed the socket shield technique [15, 20, 24, 26, 42, 43].

Though both techniques yielded 100% implant survival rate, the SS resulted in two external shield exposures encountered in the first month follow-up (20% complication rate). One of the exposure cases which was for maxillary central incisor submerged implant was due to a traumatic accident in that area leading to dislodgement of resin bonded provisional bridge and traumatizing the overlying soft tissue. The other small exposure in the maxillary first premolar implant was due to sharp corner of the shield in the mesiobuccal area that perforated the soft tissue. The two exposures were managed by just reducing the exposed part with high-speed diamond bur and both healed well with soft tissue coverage. Although more dimensional ridge shrinkage occurred for these two cases, there was not any soft tissue recession or esthetic compromise, and the patients were satisfied with the esthetic result and declined any connective tissue grafting. Gluckman et al. [23] in a retrospective study of 128 socket-shield cases reported 16 occurrences of exposure, four were external and 12 were internal. The authors advocated to reduce the buccal shield to the level of bone crest and to create a bevel in the coronal 2 mm of the shield o reduce the incidence of external and internal exposures.

This study presents with some limitations. Although 100% implants survival rates with minor manageable complications and maintenance of the ridge contour were achieved, this study was performed for a fairly small sample size in a particular center and was followed for only 8 months. In addition, the applied dimensional ridge change analysis only concentrated on mid-root portion rather than the entire ridge contour, and one assessor did the measurements three times, so inter-assessor agreement was not calculated. Further, some procedures like impression making and cast production cannot be performed without some inaccuracy.

Conclusions

In conclusion, the socket shield immediate implant placement produced better preservation of the ridge contour at 8-months post-extraction; however, the dual-zone technique yielded non clinically significant reduction in the ridge contour at the same follow-up. Two out of ten cases of socket shield group presented with minor manageable complications of external shield exposure with no complications reported for the dual-zone technique at 8-months follow up. Accordingly, more clinical studies comprising larger population with more variables and longer follow-ups in multiple centers are advocated. In addition, animal histological investigations are recommended to know more about the nature of tissue that intervenes between the implant and the shield.

Abbreviations

PCS: prospective cohort study

SS: socket-shield

DZ: dual-zone

FDBA: freeze dried bone allograft

CBCT: cone beam computed tomography

T: implant site (test)

C: contralateral tooth site (control)

T-C: change in facial-palatal ridge width

IT: Insertion torque

ISQ: Implant stability quotient

GBR: Guided bone regeneration

SD: Standard deviation

Declarations

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Author's contributions

Rola Shadid designed and conducted the study, wrote the manuscript, prepared all figures, and approved the final version.

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Availability of data and materials

Raw data are available in the uploaded "RESEARCH RAW DATA. xlsx " file.

Figures' files (1-10) are available in the uploaded files and not within the draft.

Ethics approval and consent to participate

The study was approved by the Arab American University scientific research council (SRC-17/18- 10) and performed according to the ethical principles of the Declaration of Helsinki of 1975, as revisited in 2013. Selected patients received thorough explanations about the provided treatment and signed a written informed consent in which all treatment risks were explained prior to being enrolled in the study.

Conflict of interest

The author declares no conflicts of interest linked to this study.

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Figures

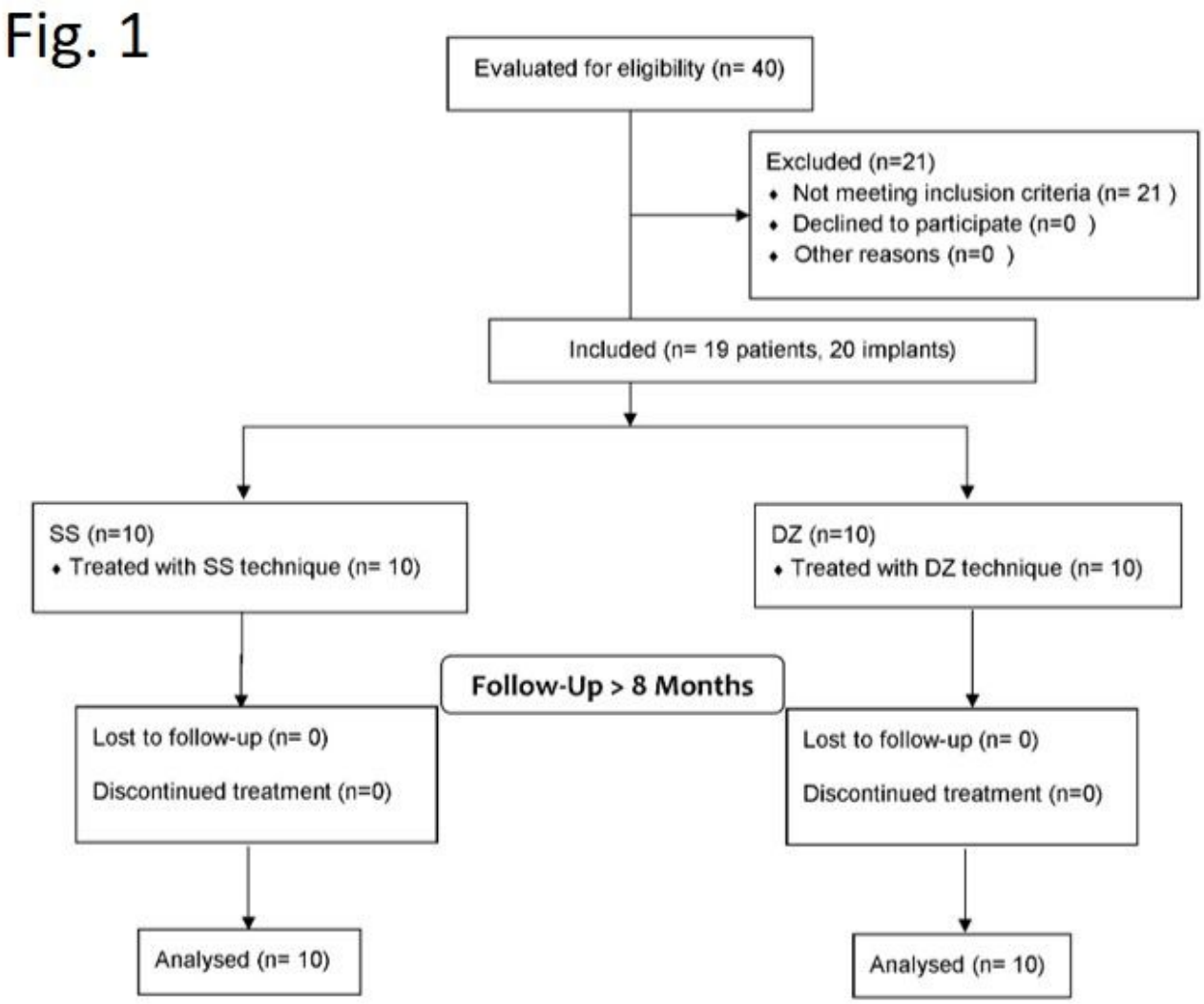


Figure 1

Flow diagram of patient selection

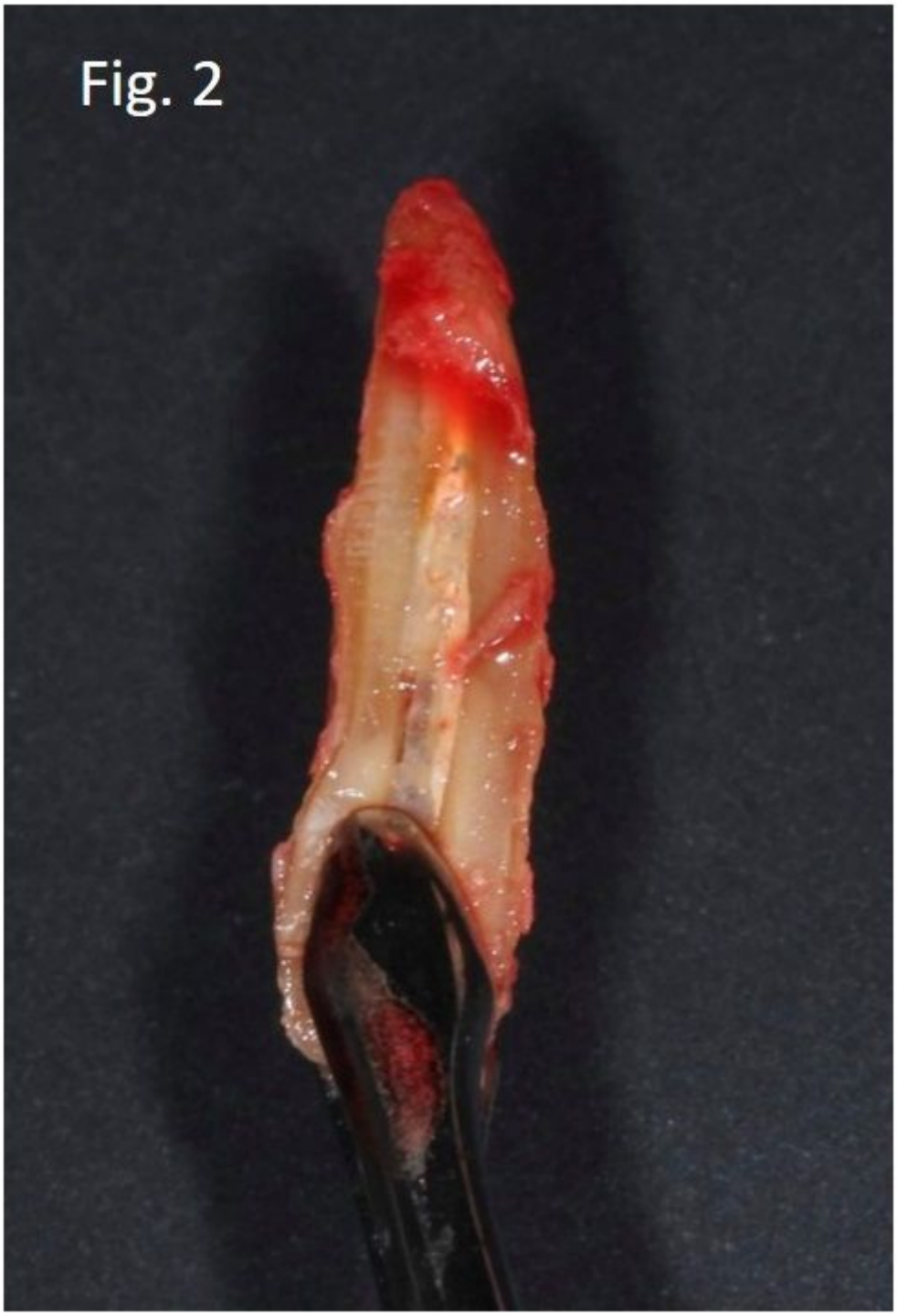


Figure 2

The apex was removed with the palatal portion of the root for SS preparation.

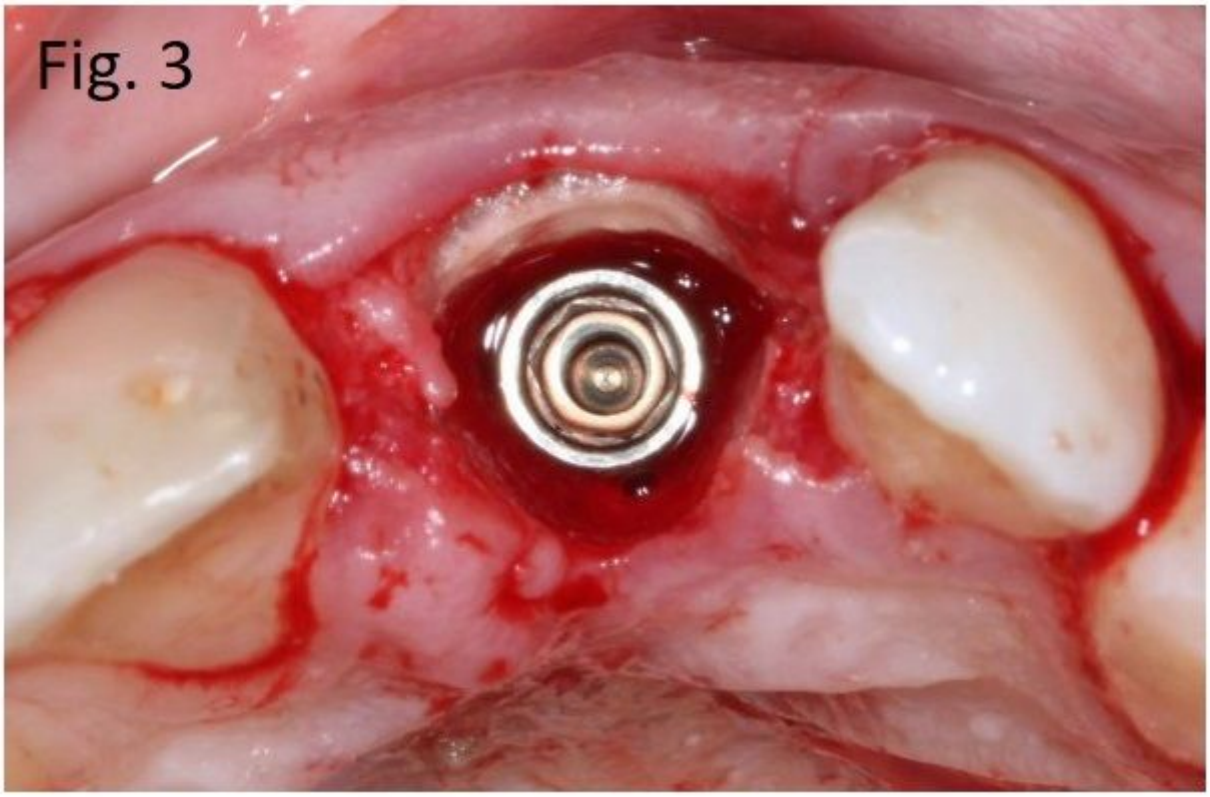


Figure 3

Incisal view showing implant placement palatal to prepared buccal shield.

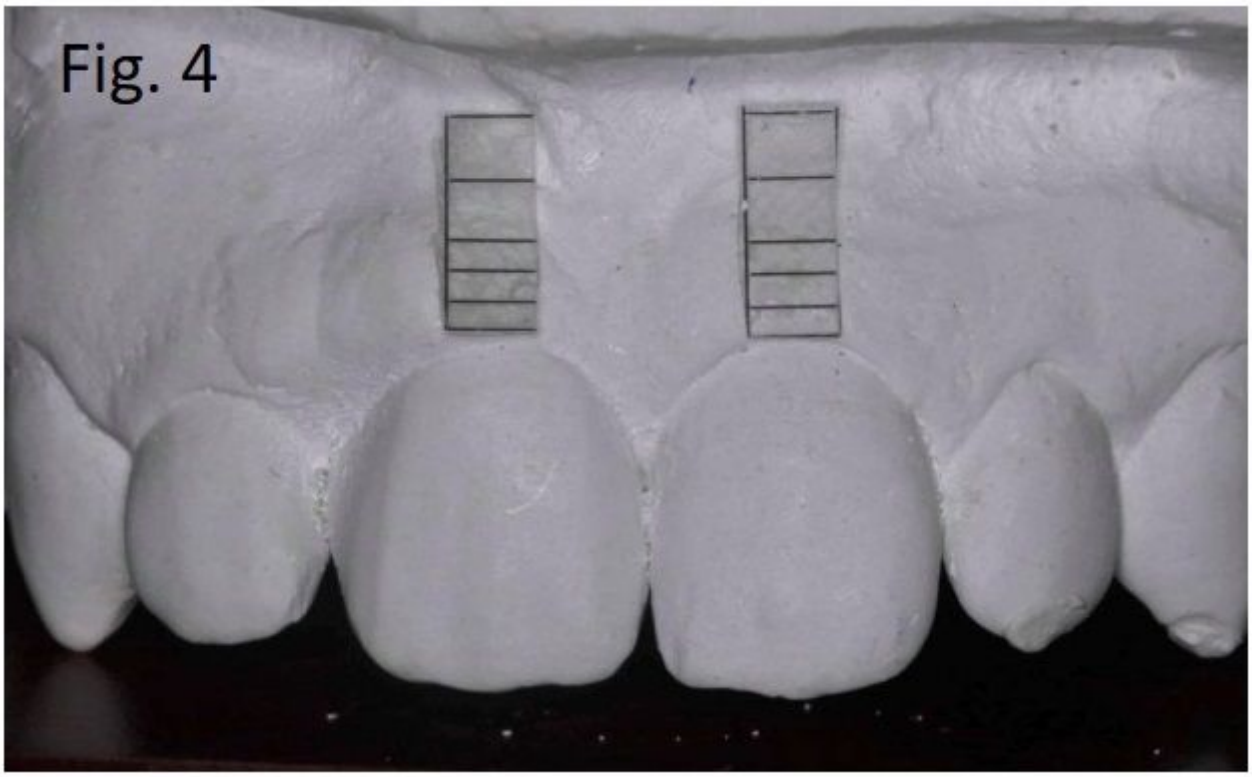


Figure 4

Cast with six designated points starting from gingival margin (0, 1, 2, 3, 5 and 7mm) on both the implant site (T) and contralateral tooth site (C).

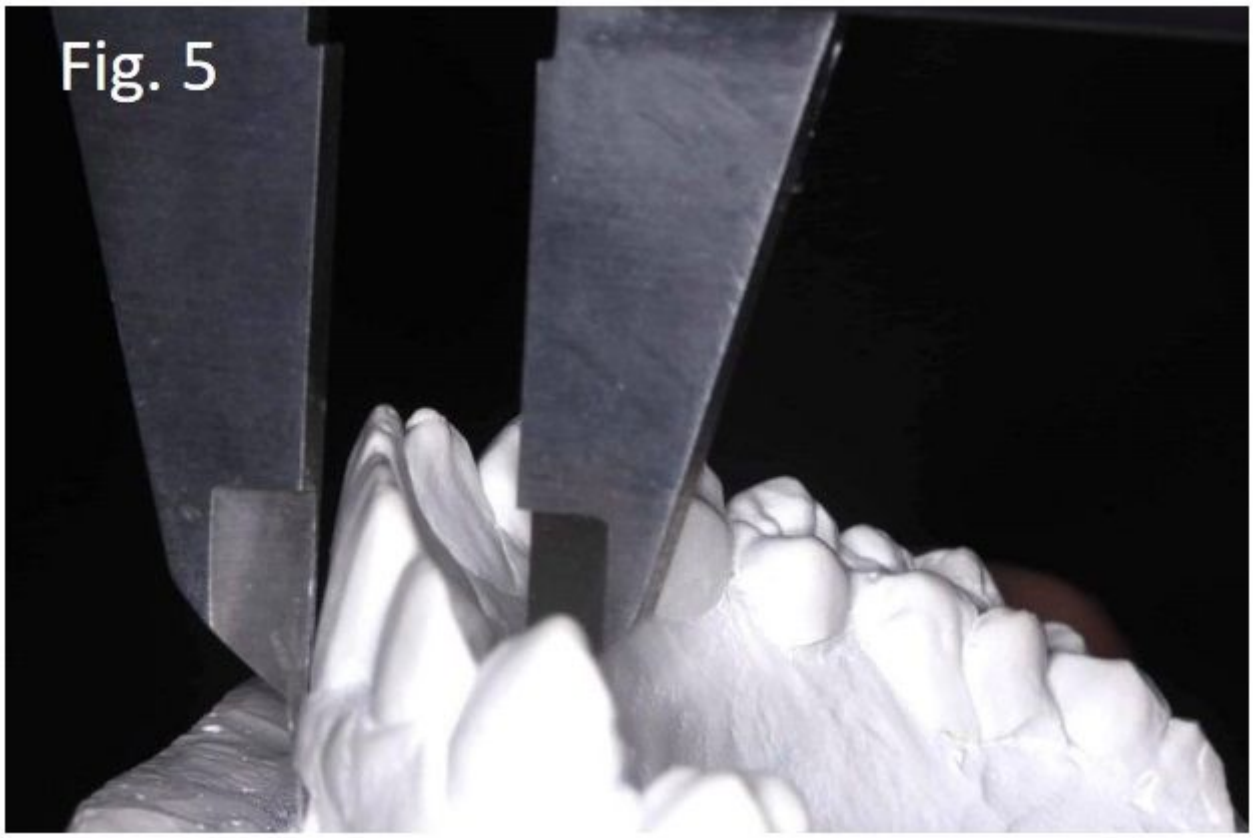
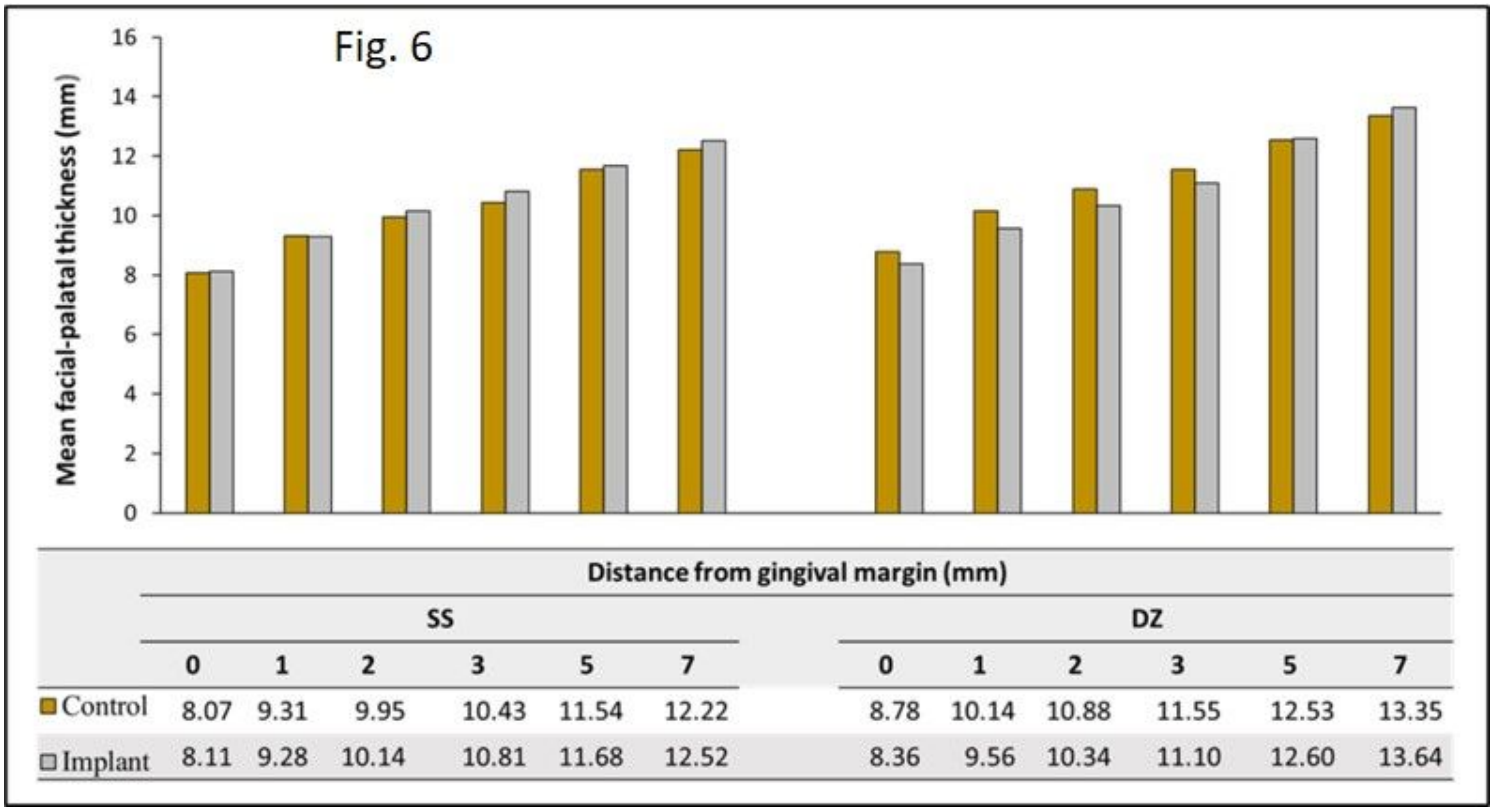


Figure 5

Measurement of facial-palatal ridge width with electronic digital caliper of 0.01 mm resolution.



	Distance from gingival margin (mm)											
	SS						DZ					
	0	1	2	3	5	7	0	1	2	3	5	7
Control	8.07	9.31	9.95	10.43	11.54	12.22	8.78	10.14	10.88	11.55	12.53	13.35
Implant	8.11	9.28	10.14	10.81	11.68	12.52	8.36	9.56	10.34	11.10	12.60	13.64

Figure 6

Mean thickness of the ridge facio-palatally on the implant sites (T) and tooth sites (C) at all distances from gingival margin for SS and DZ groups.

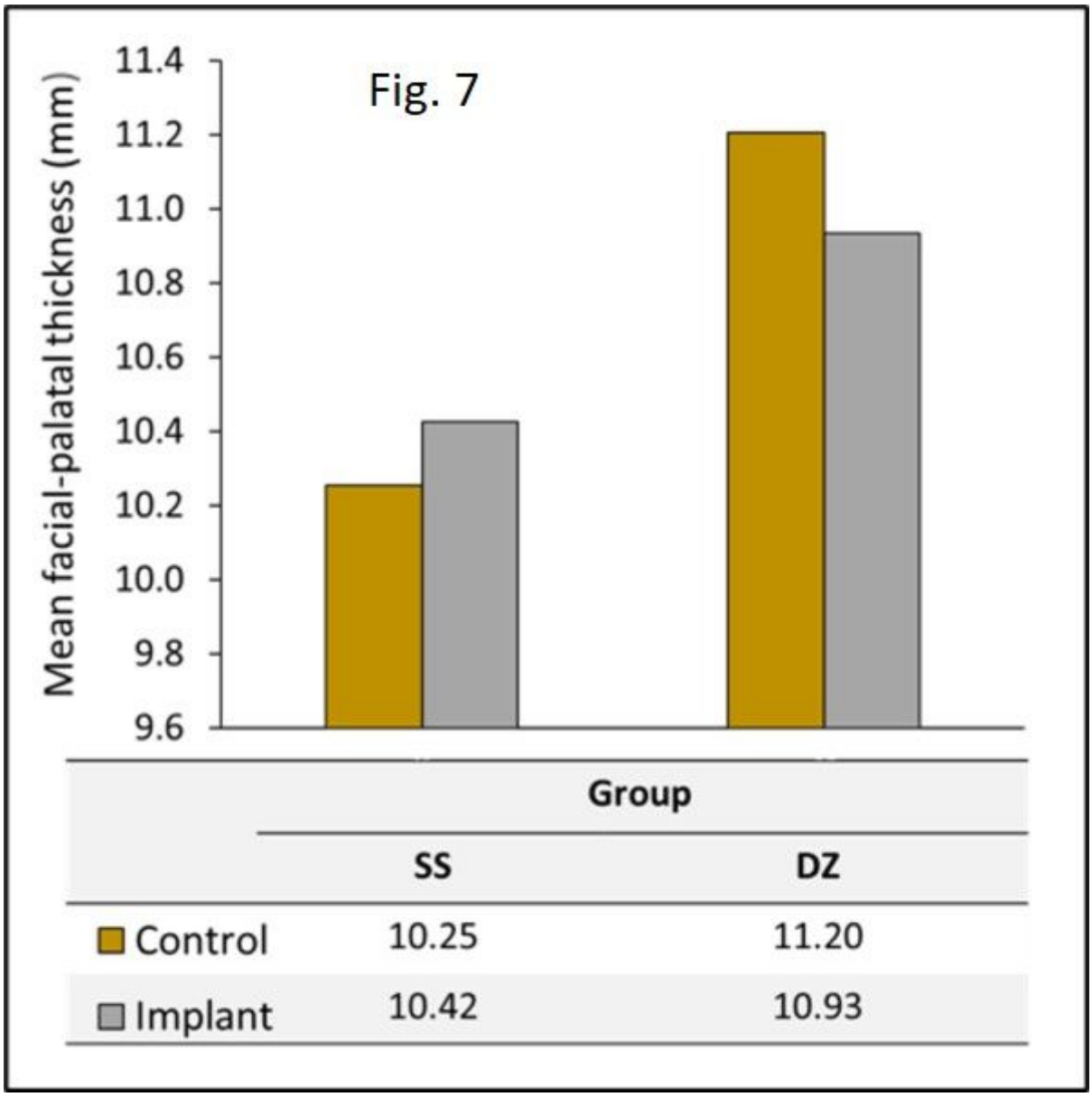
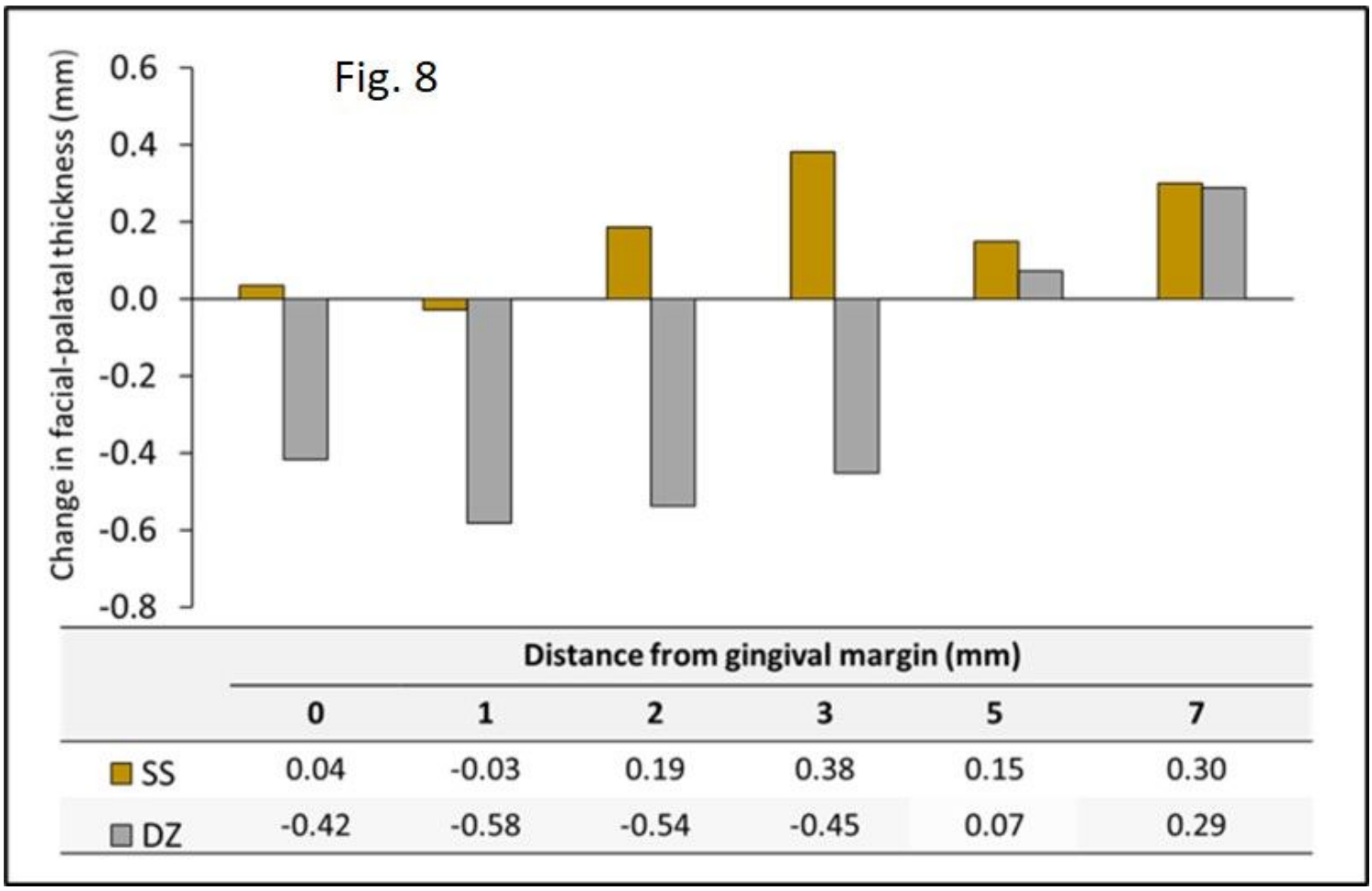


Figure 7

Mean thickness of the ridge facio-palatally on the implant sites (T) and tooth sites (C) arranged by group type (SS, DZ).



	Distance from gingival margin (mm)					
	0	1	2	3	5	7
SS	0.04	-0.03	0.19	0.38	0.15	0.30
DZ	-0.42	-0.58	-0.54	-0.45	0.07	0.29

Figure 8

Mean facial-palatal ridge contour change (T-C) at all distances from gingival margin for SS and DZ groups.

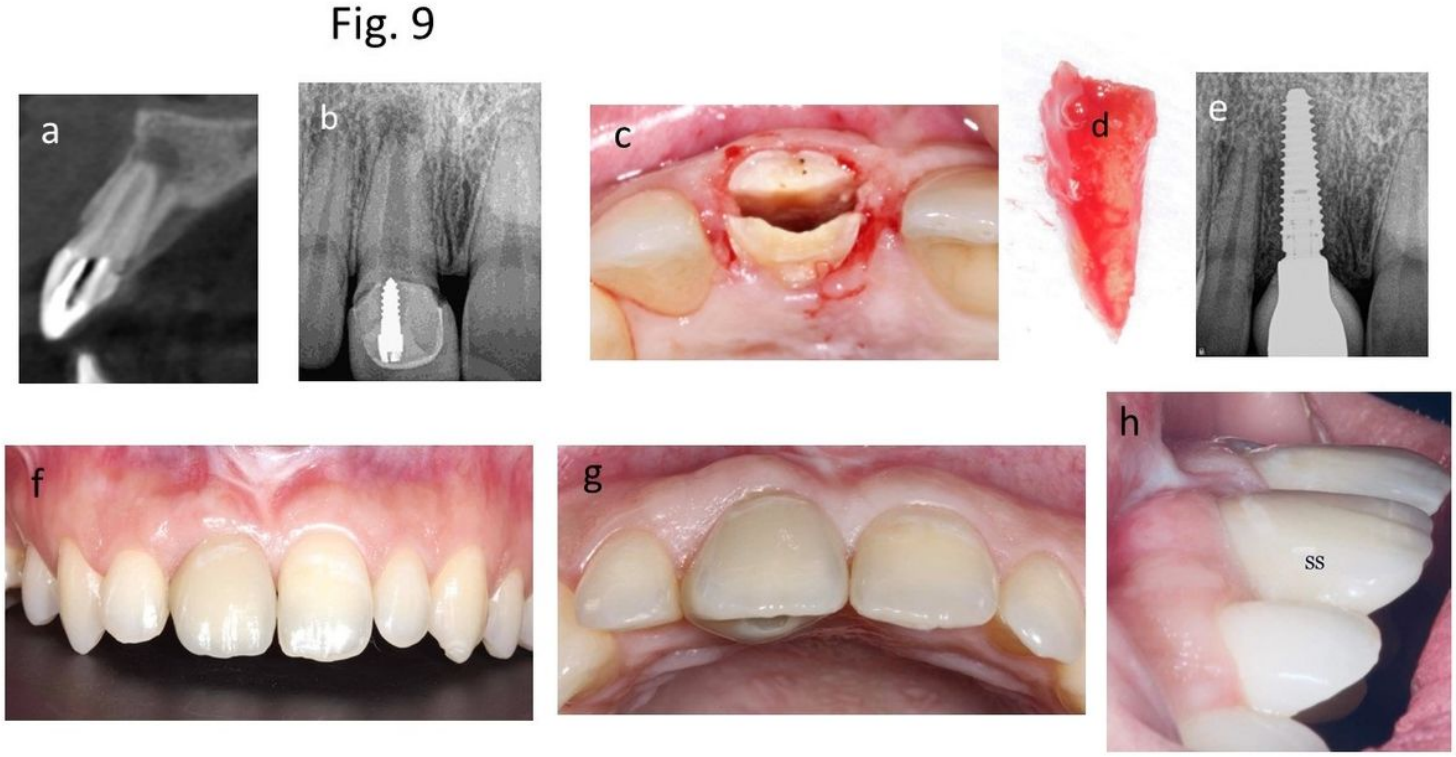


Figure 9

Clinical images and radiographs of SS case replacing maxillary right central incisor (a) Pre-operative periapical radiohraph; (b) cross-sectional view of the preoperative CBCT of right central incisor; (c) the sectioned root before palatal fragment removal; (d) The removed palatal segment; (e) postoperative periapical radiograph at 7 months; (f) frontal view of the definitive crown at 14 months; (g) incisal view of definitive crown at 14 months; (h) lateral view of definitive crown at 10 months. CBCT: cone beam computed tomography

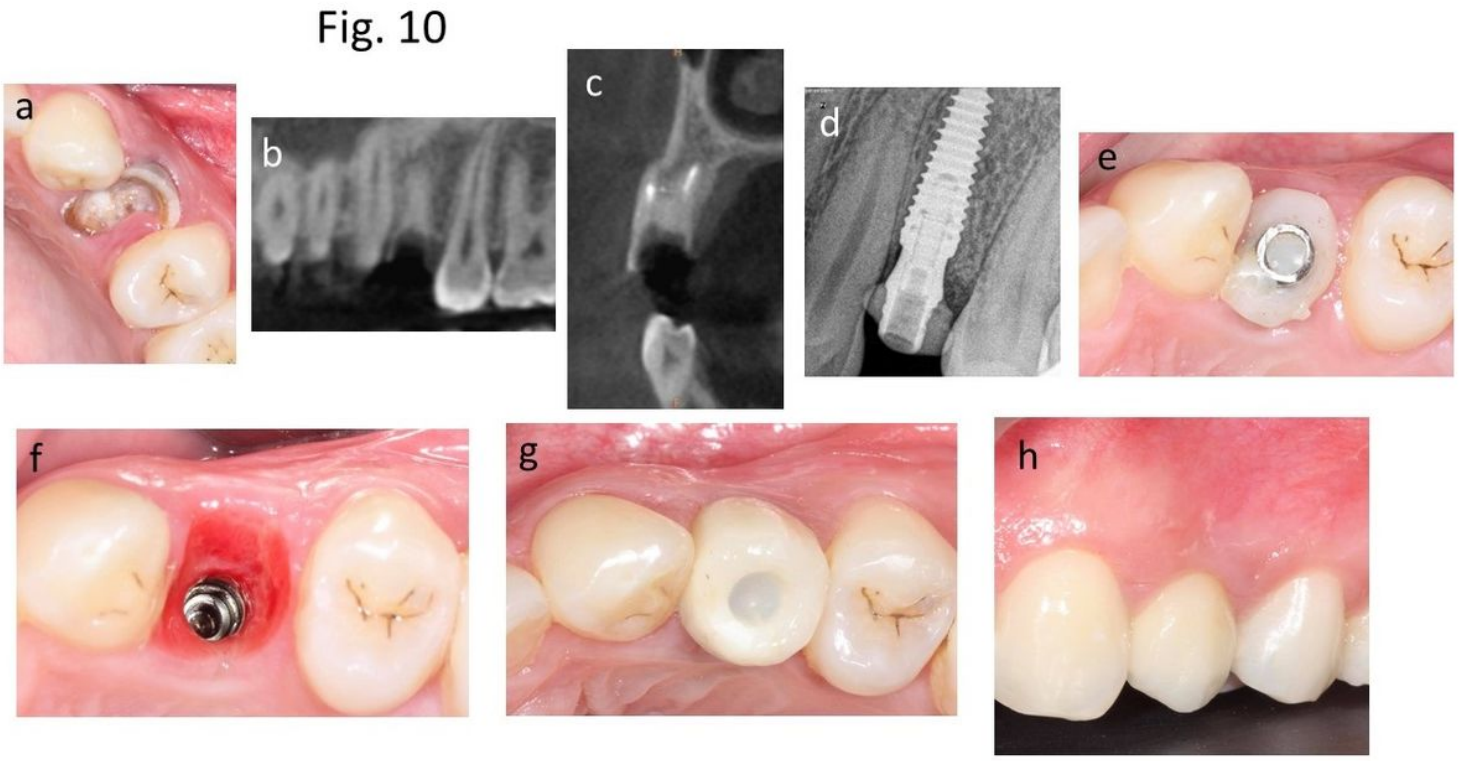


Figure 10

Clinical images and radiographs of DZ case replacing maxillary left first premolar (a) Pre-operative occlusal view; (b) panoramic view of the preoperative CBCT; (c) cross-sectional view of the preoperative CBCT of left first premolar; (d) periapical radiograph post-surgery; (e) occlusal view with customized healing abutment at 3 months; (f) occlusal view of the healed peri-implant mucosa at 7 months; (g) occlusal view of the definitive crown at 15 months. Note the ridge contour collapse that occurred facial to the implant; (h) buccal view of definitive restoration at 15 months. CBCT: cone beam computed tomography