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EVALUATION OF A DUAL SOCKET PRESERVATION TECHNIQUE FOLLOWED BY DELAYED DENTAL IMPLANT PLACEMENT (CONTROLLED CLINICAL AND RADIOGRAPHIC STUDY)

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ABSTRACT

INTRODUCTION: Autogenous teeth have the potential to be employed as a bone graft material that is both osteoconductive and osteoinductive. Dentin and bone have comparable biochemical features (80% hydroxyapatite crystals and 20% type I collagen), and dentin also includes growth factors such as insulin-like growth factor II (IGF-II), transforming growth factor (TGF-b), and bone morphogenic protein (BMP).

OBJECTIVES: The aim of this study was to evaluate socket preservation using a combination of both socket shield technique and grafting. Alloplastic bone graft was compared to autogenous graft of dentin (prepared from the palatal part of the tooth) using a split-mouth design.

MATERIALS AND METHODS: Seven patients received maxillary implants in previously preserved extraction sockets using alloplastic graft material (Beta-Tricalcium Phosphate) with socket shield technique on the right side and autogenous dentin graft with socket shield on the left side. Crestal bone loss, bone density and implant stability were evaluated at three points of the treatment plan. Preoperatively before grafting and socket shield preparation, Post-grafting three months after socket preservation with the dual technique just before implant placement and finally three months after implant placement.

RESULTS: Sockets preserved using both socket shield technique and autogenous dentin graft showed a statistically significant higher Implant stability and higher bone density than sockets of the contralateral side preserved with socket shield and alloplastic graft material.

CONCLUSIONS: Autogenous dentin graft, combined with socket shield technique gave very promising outcomes as a dual-socket preservation method.

KEYWORDS: Implants, Autogenous Demineralized tooth graft, Alloplast, socket preservation.

RUNNING TITLE: Evaluation of implant in a dual-socket preservation technique.

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INTRODUCTION

Internal changes characterize socket healing that leads to the creation of bone within the void, as well as external/dimensional changes that contribute to the reduction of alveolar ridge height and width following tooth extraction (1). Preservation refers to the upkeep of the socket, which is the height and width of the space left when a tooth is extracted. To retain bone height, breadth, and density, graft material or scaffold is immediately placed into the socket of a removed tooth. (2). Alveolar ridge preservation (ARP) treatments have been developed to preserve an appropriate ridge shape in regions where aesthetics is a concern, as well as to avoid alveolar ridge atrophy and sustain adequate bone dimensions for implant insertion. (3).

However, while these strategies suggested ways to preserve cortical bone, none of them prevented cortical bone recession after implant insertion. The loss of the appropriate periodontal ligaments is thought to be the cause of crestal bone loss after tooth extraction. It follows logically that root persistence might help to prevent resorption (4). In the 1970s, Casey and Lauciello (5) were the first to use the root subsurface concept to keep the ridge contour for complete denture fabrication. Hurzeler et al. (4) introduced the socket shield approach in 2010, leaving the buccal portion of the distal root 1 mm coronal to the buccal bone plate. The significance of bone grafting between the implant and the labial shield has been reviewed (6). Gluckman suggested that further studies are recommended to investigate the importance of bone

grafting of the gap described in the modified socket shield technique (7).

Sirompas et al.,(8) conducted a research with the highest nubmer of 250 socket shield technique(SST) documented, His study demonstrated that SST is both safe and dependable, with very few biologic consequenses.

The current gold standard for bone repair is autogenous bone, although it has drawbacks such as surgical complications, limited accessible bone, and graft resorption. Autogenous dentin is a possible bone replacement because it has a comparable composition to the alveolar bone. The major organic component of dentin, type I collagen, functions as a scaffold in the mineralization of bone. Growth factors like morphogenetic proteins also stimulate bone development by causing osteoblasts to differentiate (9).

Autogenous teeth have the potential to be employed as a bone graft material that is both osteoconductive and osteoinductive. (10, 11). Apart from the fact that dentin and bone have a roughly comparable biological composition (80% hydroxyapatite crystals and 20% type I collagen (12), it also contains growth factors that are encountered in bone, such as insulin-like growth factor II (IGF-II), transforming growth factor (TGF-b), and bone morphogenic protein (BMP) (13).

Dentin also includes several proteins that are abundant in bone, such as osteopontin, bone sialoproteins, dentin sialoproteins, and osteocalcin, which makes it a viable bone grafting material. Bone and dentin have similar characteristics, and multiple investigations have shown that bone substituted from dentin causes osteogenesis. BMP, which is found in demineralized dentin matrix (DDM) and bone, is a key stimulant with osteoinductive characteristics. (14). Bone calcification is aided by non-collagenous dentin proteins including osteocalcin, osteonectin, phosphoprotein, and sialoprotein (15).

The DDM is a grafting material that is not only a BMP2 transporter but also a scaffold for bone-forming cells (16). BMP-2 AND BMP 7 provide the most promising results for the enhancement of bone repair. The property of BMP can induce de novo bone formation. Despite the fact that BMP formed from dentin differs from that obtained from bone, they both have the same action in the body (17).

LIM mineralization proteins 1 Present in dentin has the property of regulation proliferation and specialization of osteoblast and hence bone formation and mineralization of dentin matrix (18).

In this study, socket preservation was evaluated using a combination of socket shield and grafting. Alloplastic bone graft was compared to an autogenous graft of dentin (prepared from the palatal part of the tooth) using a split-mouth design in terms of bone dimensional changes, bone density, and implant stability.

SUBJECTS AND METHODS

Patients' selection

Seven patients were enrolled from the Outpatient Clinic of Alexandria Main University Hospital and operated in the Oral and Maxillofacial Surgery Department, Faculty of Dentistry, Alexandria University, Egypt.

Informed consent

Informed written consent was obtained from all participating patients after explaining the procedure, possible complications, and their rights to withdraw from the study. The Ethics committee of the Faculty of Dentistry, Alexandria University, approved the study. This study was registered at clinicaltrials.gov and granted an ID number: NCT05047861

Sample size estimation

The sample size was estimated assuming 5% alpha error and 80% study power. The mean change in buccal bone height using autogenous fresh demineralized tooth (AFDT) graft after 3 months was calculated to be 2.66 with pooled SD= 0.78 (9). However, the calculated mean change using alloplastic material (β-TCP) after 3 months= -0.5 with pooled SD=2.68 (19). Based on the comparison of means in a split-mouth study where 2 implants would be placed for each case, the total sample size was calculated to be 7 cases. They were subjected to split-mouth design to evaluate the clinical and radiological outcome of implants placed in preserved sockets using socket shield technique with two different types of bone graft, taking into consideration 5% level of significance and 1% Precision using Z test.

Inclusion criteria

1- Age range of 20 to 50 years old, regardless of gender

2- In the maxillary aesthetic areas, one or more non-restorable fractured or badly decayed incisors, premolars.

3- Labial/buccal periodontal tissues in good condition.

4- Enough bone volume to allow for adequate implant placement.

5- Non-Smoking participants.

6- The ability to read, comprehend and sign an informed consent.

Exclusion criteria

1- A medical history that precludes oral surgery as immunocompromised state, uncontrolled diabetes, ongoing oral/maxillofacial radio or chemotherapy, treatment with oral and/or intravenous Bisphosphonates.

2- Periodontal disease that has not been repaired.

3- On the buccal side, vertical root cracks.

4- Horizontal tooth fractures below the level of the alveolar bone.

5- Resorptions on the outside or inside of the tooth structure.

Grouping

Patients received a maxillary implant in a previously preserved socket using an autogenous dentin graft with socket shield on the left side and alloplastic graft material with socket shield technique on the right side.

1. Group I (Socket shield technique with autogenous dentin graft).
2. Group II (Socket shield technique with alloplastic graft material).

Regarding assignation each side for one of the graft types to all the patients, just to minimize any possible errors or mistakes that could happen by the operator during results recording and measuring specially the long duration of the treatment plan and its three surgical phases.

Operative procedure

I. Surgical procedure

A. Tooth shield preparation:

Under abundant irrigation, decoronation the crown of the doubtful tooth with a chamfer diamond bur and a large-head round diamond bur till the bone crest level. Using a long shank fissure bur, section the root along the long axis into buccal and palatal halves. The palatal root fragment was recovered using a microperiotome. The remainder of the buccal root fragment was thinned and concaved. To guarantee resistance to fracture and resorption, the buccal root fragment should be at least 1.5 mm thick. Using a large-head round diamond bur, bevel the coronal section of the shield to provide a palatal slope for a superior emergence profile. In order to put the implant palatally, the socket shield must be checked for immobility**. (Figure 1)**

In one of the cases Buccal fragment after preparation had a slight movement. After finishing the grafting phase, the buccal fragment left in place buccally to the graft for the next phase. After 3 months post-grafting the shield reattached to the buccal bone and no movement was noticed and implant placed safely.

B. Graft preparation and placement:

After final preparation of socket shield, the palatal part of the tooth was turned into a graft material by means of grinding tools and chemical processing according to the previously used protocol for dentin graft preparation by Melek and El Said (9). Regarding our technique of graft preparation, Linamax pulverize blade grinder was chosen as it is autoclavable with capacity of 100 g, voltage 220v/50HZ, power 750 W, Speed 25000 r/min and maximum fineness of 20-100µm. Tooth particles were crushed by collision with blunt edged stainless steel blade. Sieving of the grinded tooth particles was done using two Gilson high precision stainless steel wire sieves with the top sieve 1200 µm and the bottom one 300. Any particles larger than 1200 µm were considered to be too coarse and not to be used and any particles smaller than 300 µm were also discarded as this tiny particle (less than 300 m) is thought to be inefficient for bone grafting (9).

The graft was done at the extraction site using either alloplast beta-tricalcium phosphate (β-TCP) at the right side or autogenous dentin graft at the left side. After filling the socket remaining gap by either graft, coverage by collagen membrane was done on top followed by suturing using vicryl absorbable suture, with continuous and figure of eight suturing technique and then the surgical site was left for three months. **(Figure 1)**

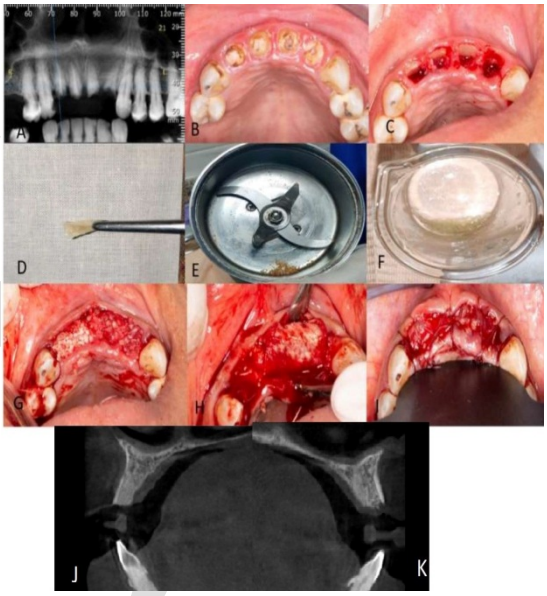

Figure (1): (A) Preoperative x-ray **(B-C)** Tooth shield preparation. **(D-I)** Graft preparation and placement. **(J)** X-ray three months post-grafting shows alloplast (TCP) behind the socket shield. **(K)** X-ray three months post-grafting shows autogenous Dentin Graft behind the socket shield.

C. The implant placement procedure:

Three months after grafting, the implant was placed using the drilling sequence recommended by the implant manufacturer. Drilling began by contacting the palatal wall, ensuring that the buccal root fragment remained intact. After implant bed preparation, an implant from SuperLine Implant System (Dentium Co.,Ltd, South Korea) was placed. Immediately thereafter, the implant's stability was assessed using resonance frequency analysis (RFA) using a specialized device (Mega ISQ, Megagen, South Korea). One week following surgery, the sutures were removed. **(Figure 2)**

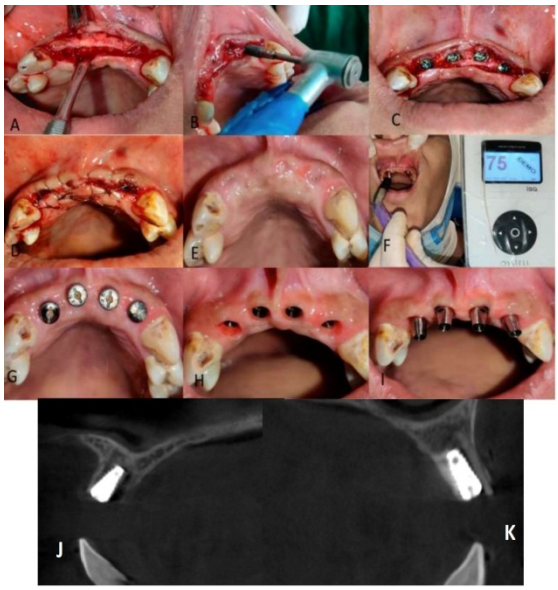

Figure (2): (A-D) Implant placements. **(E-G)** Three months after implant placements. **(H-I)** Two weeks after healing abutments. **(J)** X-ray three months after implant placement at the alloplast side palatally to the socket shield. **(K)** X-ray three months after implant placement at the autogenous dentin graft side palatally to the socket shield.

II. Postoperative care

Post-operative instructions: All patients were given comprehensive oral hygiene care and postoperative instructions, including cold fomentation for the first day in addition to soft diet, high protein, high calorie diet and fluids for 2 weeks postoperatively.

Postoperative medication: They were advised to take the prescribed medications, which include:

- Amoxicillin 875mg + Clavulanic acid 125mg (Augmentin 1g Glaxosmithkline [GSK]) every 12 hours for 7 days.
- Non-Steroidal Anti Inflammatory drugs (Cataflam 50 mg Novartis) every 8 hours for 4 days.
- Chymotrypsin +Trypsin 300E.A.U (Alphintern, Amoun Company) every 8 hours for 5 days.
- 0.12% chlorhexidine mouth (Hexitol, Arab drug Company) wash 3 times daily for 2 weeks.

III. Restorative procedure

All implants were loaded and restored with definitive restoration provided 3 months after implant insertion.

IV. Follow-up phase:

Patients were urged to return one week after surgery. Following that, follow-up sessions were set on a monthly basis for the next three months. Provisional restorations were eventually replaced with long - lasting restorations (metal-ceramic or full ceramic crowns).

V. Clinical Evaluation:

All patients were followed up and assessed for the success of the surgical procedure using the following criteria:

- The presence of postoperative pain with the help of visual analog scale [0-10] (VAS).
- Postoperative edema following surgery. This was evaluated in the first week after surgery and was measured according to the following score: None (no inflammation) Mildly (intraoral swelling confined to the surgical area) Moderately (extraoral swelling in the surgical area) Extremely severe (extraoral swelling spreading beyond the surgical area).(9)
- Implant Stability was measured by using Osstell ISQ for both groups at implant placement time, and 3 months postoperative at the prosthetic loading phase.
- Detection of any biological complications affecting the shield, dental implant, and/or the peri-implant hard and soft tissues.

VI. Radiographic evaluation: The CBCT data was analyzed using OnDemand3D software version 1.0 (Build 1.0.9.3223) to evaluate both bone density and marginal bone level around dental implants.

A. Bone density and osseointegration around implants: Using OnDemand3D software a virtual implant was placed at the grafted site to calculate the mean bone density value automatically. The virtual implants were selected from implant database to match the same implant type, parameters and position of the actual implant placed at the grafted site in our study. The implant was dentium super line. Mean bone density was measured at three points of the treatment plan. The first one Pre-operative before grafting and socket shield preparation, The second after three months of the grafting and just before the implant placement and the third three months after implant placement.

B. Crestal bone level: CBCT was performed for all patients immediately at the time of implant placement (three months after socket preservation using socket shield and bone grafting) and three months postoperatively after implant placement. The measurements of bone height was taken immediately at the time of implant placement and three months postoperatively.

Statistical analysis of the data

The IBM SPSS software program version 20.0 was used to examine the data (Armonk, NY: IBM Corp). The significance of the acquired results was determined at the 5% level. To compare two intervals, use a paired t-test for normally distributed quantitative variables. ANOVA with repeated measurements is used to evaluate more than two periods or stages of normally distributed quantitative variables, and the Post Hoc test (Bonferroni adjusted) is used for pairwise comparisons.

RESULTS

Clinical Parameters

Mean Numeric Rating Scale (VAS) was 2.29 ± 1.38 for group I and 1.71 ± 1.11 for group II. There was a statistically non-significant difference between the two groups (p=0.285). Mean Pain duration (days) was 1.86 ± 0.69 days for group I and 1.29 ± 0.49 days for group II. There was a statistically non-significant difference between the two groups (p=0.102). Regarding Oedema, 2 patients had (28.6%) mild edema and 5 patients had (71.4%) Moderate edema in group I 6 patients (85.7%) mild edema and 1 patient had (14.3%) was Moderate edema in group II. There was a statistically non-significant difference between the two groups (p=1.000).

Bone density (Table 1)

Preoperatively before grafting Bone Density was 1113.3 ± 107.9 for group I and 1168.9 ± 142.6 for group II, there was a statistically non-significant difference between groups (p=0.176). Post-grafting Bone Density was 1299.4 ± 185.8 for group I and 1446.6 ± 132.5 for group II, there was a statistically a significant difference between the groups (p=0.030*). Group II showed a significant higher Bone Density than group I. Post-implant Bone Density was 1407.1 ± 88.27 for group I and1288.4 ± 55.39 for group II, there was a statistically a significant difference between groups (p=0.001*). Group I showed a significant higher Bone Density than group II.

Bone height (Crestal bone loss) (Table 1)

The difference between preoperative bone height and the bone height 3 months after socket preservation was -0.16 ± 0.08 mm for group I and 0.20 ± 0.10 mm for group II, there was a statistically non-significant difference between the two groups (p=0.576). The difference in bone height between the pre-implant placement time and 3 months postimplant insertion was-0.10 ± 0.04 mm for group I and -0.15 ± 0.10 mm for group II, there was a statistically non-significant difference between the two groups (p=0.142).

Implant stability (Table 1)

Implant stability by ISQ OSSTELL at time of implant insertion was 72.71 ± 4.89 for group I and 69.57 ± 3.05 for group II, there was a statistically non-significant difference between groups (p=0.057). Implant stability by ISQ OSSTELL 3 months after implant insertion was 73.71 ± 2.81 for group I and 71.43 ± 2.99 for group II, there was a statistically significant difference between the two groups (p=0.022*). Group I showed a significant higher Implant stability by ISQ OSSTELL than group II.

Both Group I and Group II showed a statistically a significant increase in bone density form the Post-grafting period to the Post-implant period (p<0.001*).

Table (1): Comparison between the two-split mouth according to bone density, Change in bone height, and Implant stability by ISQ.

	Group I	Group II	p
Bone Density			
Preoperative	1113.3 ± 107.9	1168.9 ± 142.6	0.176
Post-grafting	1299.4 ± 185.8	1446.6 ± 132.5	0.030*
Post-implant	1407.1 ± 88.27	1288.4 ± 55.39	0.001*
Change in bone height			
Pre-operative – 3months after bone graft	-0.16 ± 0.08	-0.20 ± 0.10	0.576
Pre-implant placement and 3months after	-0.10 ± 0.04	-0.15 ± 0.10	0.142
Implant stability by ISQ			
Time of implant insertion	72.71 ± 4.89	69.57 ± 3.05	0.057
3 months after implant insertion	73.71 ± 2.81	71.43 ± 2.99	0.022*

SD: **Standard deviation** **t: Paired t-test**
p: p value for comparing between the two split mouth
*: Statistically significant at p ≤ 0.05

The Comparison between the three periods according to bone density in each split mouth showed statistically significant difference at the Dentin side (Group I) when compared between preoperative and post-implant periods. **(Table 2)**
Also, a statistically significant difference at the alloplast side (Group II) was detected when compared between preoperative and post-grafting and between post-grafting and post-implant periods. **(Table 2)**

Table (2): Comparison between the three periods according to bone density in each split mouth

Bone density	Pre-operative	Post-grafting	Post implant	P
Group I				
Min. – Max.	1001.0 – 1291.0	1137.0 – 1669.0	1288.0 – 1528.0	<0.001*
Mean ± SD.	1113.3 ± 107.9	1299.4 ± 185.8	1407.1 ± 88.27	
Sig. bet. periods	p_1=0.052,p_2=0.002*,p_3=0.242			
Group II				
Min. – Max.	988.0 – 1334.0	1236.0 – 1607.0	1215.0 – 1380.0	<0.001*
Mean ± SD.	1168.9 ± 142.6	1446.6 ± 132.5	1288.4 ± 55.39	
Sig. bet. periods	p_1=0.012*,p_2=0.081,p_3=0.015*			

SD: Standard deviation F: F test (ANOVA) with repeated measures, Sig. bet. periods was done using Post Hoc Test (adjusted Bonferroni)
p: p value for comparing between the three studied periods

p_1: p value for comparing between Preoperative and Post-grafting
p_2: p value for comparing between Preoperative and Post-implant
p_3: p value for comparing between Post-grafting and Post-implant
*: Statistically significant at $p \leq 0.05$

DISCUSSION

In the present study, we selected the Socket Shield Technique because it preserves the root socket and prevents buccal wall collapse by maintaining vascularity and periodontal ligament. The socket-shield technique (SST) is a predictable treatment with less surgical intervention, a significantly shorter treatment time, and a better cosmetic outcome (20). It tries to keep the buccal two-thirds of the root in the socket, as well as the periodontium, bundle bone, and buccal bone intact. (4).

Santhanakrishnan et al., (20) examined soft and hard tissue alterations in the aesthetic zone of the maxilla after immediate implant placement (IIP) with and without the socket shield technique (SST). When compared to the IIP group, the SST group showed modest loss in crestal bone thickness (CBT) at the end of 6 months. Changes in Crestal Bone Thickness (CBT) were chosen as the major outcome variable because they have a negative impact on the soft and hard tissues around the implant. The CBT was assessed six months after the implant was placed, because the majority of the changes occur at this period after the tooth is extracted (21). The occurrence of a criss-cross configuration of the periodontal ligament in the SST group might be correlated with greater root socket maintenance, therefore minimizing buccal wall collapse by conserving the vascularity and periodontal ligament.

To our knowledge, this is the first research to investigate implant placement in a preserved socket employing both the socket shield technique and autogenous dentin graft. For a more accurate non-biased study, we used a split-mouth design for comparison using an alloplast grafting material in combination with the socket shield on the contralateral side. Regarding our grinding method of the denting graft is both safer and more cost-effective than the newly created tooth-mill. To save time, smart dentine grinders integrate the grinding and sieving procedures; nonetheless, they create calcified autogenous dentine grafts. However, they have the disadvantage of lacking the demineralization phase, which is required to expose the biological dentine matrix and growth factors that drive bone production, leading in a prolonged healing period for bone (22).

Also, the usage of acetic acid and pareacetic acid has affected the bacterial effect development in the autogenus fresh demineralize tooth (AFDT) graft owing to its strong oxidizing activity, which oxidizes the exterior cell walls of microorganisms. Proteins will be denatured, cell wall permeability will be compromised, and sulfhydral and sulphur linkages in proteins, enzymes, and other metabolites will be oxidized, causing microorganisms to quickly deactivate (22). In the presence of organic materials, peracetic acid at 200-500 ppm will inactivate gram-positive and gram-negative bacteria, fungi, and yeasts in 5 minutes (22).

In the present study, the autogenous graft of dentin, prepared from the palatal part of the extracted tooth, combined with socket shield technique gave very promising outcomes. The results showed that, post-implant bone density was 1407.1 ± 88.27 for group I (socket shield technique with autogenous dentin graft) and 1288.4 ± 55.39 for group II (socket shield with alloplast), and the difference between the two groups was statistically significant. Also, Group I (socket shield technique with autogenous dentin graft group) showed a statistically significant higher Implant stability than group II (socket shield with alloplast group).

Melek and El Said (22) investigated studied the clinical and radiographic results of using autogenous tooth bone graft material in conjunction with injectable platelet-rich fibrin for maxillary alveolar ridge repair. When compared to pre-operative values, their results demonstrated a 30 percent increase in mean bone density over a six-month period. Moreover, the grafted location exhibited a 23.47 percent increase in mean volume. Three months after grafting, radiographic assessment of the alveolar ridge revealed a substantial mean increase in ridge width and height at the grafted region. They concluded that autogenous fresh demineralized tooth grafts made at the chairside following extractions might be regarded the gold standard for socket preservation, sinus augmentation, and filling bone deficiencies in patients with non-restorable teeth.

Our results are consistent with those of Valdec et al., (23) who augmented extraction socket with autologous, particulated dentin and implants were installed in the augmented area. Their results showed a functional and aesthetic success. Yüceer et al. (24) have also investigated the effects of autogenous dentin grafts applied in tooth extraction sockets on bone repair. The autogenous dentin graft group had higher levels of bone morphogenetic protein-2 and Runt-related transcription factor-2 expression.

Moreover, Dhuvad & Mehta (25) studied a novel bone production technique that offered a single-stage treatment, namely tooth extraction followed by autogenous dentin demineralized (ADDM) graft in the same extraction socket (ES). The use of an ADDM graft for the quick repair of an alveolar bone deficit has been shown to be a good alternative, saving money over other graft materials on the market.

The chemical makeup of the tooth and the alveolar bone are quite similar. The overall inorganic, organic, and water contents of enamel and dentin are identical to those of alveolar bone (11). Because of its osteoconductive and osteoinductive qualities, autogenous dentin grafts have comparable histology results to autogenous bone grafts, making it an ideal bone graft material (11).

Concerning bone density, Group II showed a significantly higher bone density than group I three months after grafting. This might be due to the higher condensability of the alloplast material. This may have resulted in higher Bone Density at the time of implant installment. However, three months after implant insertion (6 months after grafting), the results were reversed in favor of the dentin graft group which may indicate better bone regeneration and maturation in this group.

Within the limitations of our study here we found out that the dual technique of socket preservation (Socket shield technique with bone graft) was a successful socket preservation procedure to enhance the bone formed at the extraction site. It also helps to prevent as much as possible complications of immediate implant placement after SST such as labial fenestration and mobility of the labial shield recorded in the literature (26).

CONCLUSION

Dual technique of socket preservation helps to avoid the drawbacks and limitations of solitary SST (socket shield technique). Also, autogenous dentin graft has shown more promising results than the alloplast beta tri-calcium phosphate in socket preservation for delayed implant placement.

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