 DOI: 10.21608/adjalexu.2025.357369.1590

EVALUATION OF IMMEDIATELY PLACED IMPLANT USING SOCKET SHIELD TECHNIQUE AND AUTOGENOUS DENTIN GRAFT (A RANDOMIZED CLINICAL TRIAL)

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ABSTRACT

INTRODUCTION: Many techniques have been proposed to reduce bone resorption in the anterior maxilla, including the socket shield technique (SST). Socket grafting for ridge preservation is an effective surgical technique that considerably decreases ridge alterations and atrophy after extraction.
OBJECTIVES: The current study evaluates implant stability, marginal bone level, labial bone width, and mean bone density in immediately placed implants via the socket shield technique and autogenous dentin graft in maxillary single-rooted teeth.
METHODOLOGY: Eleven patients were selected and assigned to one group: immediate implant with the socket-shield technique and dentin graft. Clinical follow-up and radiographic examinations were performed immediately after surgery and after 3 months to estimate implant stability, mean bone density, marginal bone level, and the change in the thickness of the labial cortical plate.
RESULTS: Implant stability of immediate implant placement with SST and autogenous dentin graft significantly increased from 55.09 to 69.91 after three months, the reduction in labial plate thickness was 0.35, the marginal bone level was 0.19, and the mean bone density immediately after surgery significantly increased from 1154 to 1338.4 after three months.
CONCLUSIONS: Immediate implant placement via the socket shield technique and dentin graft significantly improved implant stability after 3 months. Radiographically, there were clinically successful results of the change in labial bone thickness and marginal bone level reduction. The mean bone density around the implants significantly increased after 3 months.
KEYWORDS: Immediate, Implant, Socket shield, Autogenous, Dentin graft.
RUNNING TITLE: Implant placement using socket shield and dentin graft.

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INTRODUCTION

Vertical and horizontal resorption of the alveolar ridge usually occurs mainly on the facial side of the maxillary arch following teeth extraction (1). Teeth extraction causes periodontal ligament loss, which is the source of blood supply to the facial plate (2).
Approximately ninety percent of patients in the anterior maxilla have labial bundle bone resorption of one millimeter or less after extraction. If the ridge resorption is not reversed or reduced, it will result in a biological and esthetic compromise for future restoration (3).
Many techniques have been proposed to reduce bone resorption in the anterior maxilla, including the socket shield technique (SST), introduced by Hurzeler and his colleagues in 2010 (4).
This technique includes preserving the facial segment of a root to be extracted and immediately placing the implant. The implant is placed palatal to the shield, and in half of the patients, implants were positioned in contact with the root. Hurzeler (4) showed via histological studies that cementogenesis occurs between the implant surface and the retained root surface resulting in clinically successful osseointegration.
Socket grafting for ridge preservation is an effective surgical technique for considerably decreasing ridge alterations and atrophy after extraction (5).
Due to their constitutional osteoinductive and osteoconductive capacity, autogenous dentin grafts, used as an alternative to xenografts, allografts, and autogenous bone grafts, have led to predictable clinical and histological outcomes for guided bone regeneration in implant dentistry (6). Few studies have used the socket shield technique with an autogenous bone graft for bone preservation with immediate implant placement.
The study rationale is to assess the primary and secondary stability of immediately placed implants using the socket shield technique with an autogenous dentin graft in maxillary single-rooted teeth. It also aims to evaluate the thickness of the

labial cortical plate, estimate the marginal bone level, and gauge bone density.

MATERIALS AND METHODS

Ethical approval

The Research Ethics Committee, Faculty of Dentistry, Alexandria University (IRB No. 0629-02/2023, IORG 0008839) gave ethical approval. The clinical trial was registered with no. NCT06566287.

Study design

A prospective single-arm clinical trial was conducted according to the consort guidelines. Eleven patients with non-restorable maxillary anterior teeth were randomly selected for the study. Patients were assigned to one group: immediate implant with socket shield technique and autogenous dentin graft.

Study setting

Patients were referred to the Department of Oral and Maxillofacial Surgery of the Faculty of Dentistry, Alexandria University.

Study sample and sample size estimation

The sample size was estimated, assuming a 5% alpha error and 80% study power. According to Rowan et al. (7), the mean (SD) implant stability after 3 months was 65.60 (9.33) for the immediate implant placement, the sample size was ten patients per group. This number increased to 11 patients per group to compensate for patients lost to follow-up cases. Total sample size = 11 patients. The sample size was based on Rosner's method (8) and was calculated by G*Power 3.1.9.7 (9).

Eligibility criteria

Inclusion criteria

1- Patients aged 18-50 years were selected.
2- Patients with non-restorable maxillary anterior teeth when the labial cortical plate was still intact and whose thickness was found to be <2mm via cone-beam computed tomography (CBCT).
3- Patients with a health status according to the American Society of Anesthesiology (ASA) I and II criteria (10).
4- Patients who agree to participate in the study.

Exclusion criteria

1- Patients presenting with any systemic pathology or health condition that would inhibit the osseointegration process of the implants.
2- Perforation in the labial cortical plate observed via CBCT.
3- Patients who underwent radiation therapy or had a history of radiation within the last two years.
4- Drug or alcohol abuse.

Materials

1- Eleven implants (C-Tech Implant (Italy)). **Figure (1a)**
2- Bone crusher (Stainless steel Bone Crusher (made in Pakistan)). **Figure (1b)**
3- Dentin cleanser solution (20% ethanol + 80% sodium hypochlorite) (Dentin cleanser solution (Kometabio, New York, NY, USA)).
4- Phosphate-buffered saline (PBS) solution (PBS - Phosphate-Buffered Saline (10X) pH 7.4, RNase-free (made in China)).
5- A long shank high-speed carbide bur is required for sectioning the tooth (Carbide bur (Komet, Germany)). **Figure (1c)**
6- Osstell ISQ was used to measure implant stability (Osstell (Gothenburg, Sweden)).

Presurgical assessment

1- Scaling and oral hygiene instructions were provided for each patient 2 weeks before the surgery.
2- Cone-beam computed tomography (CBCT) was used for each patient; the purpose of CBCT was to evaluate the site for the presence of intact bone plates and, if there was any pathology, assess the position of the root, assess the labial bone thickness, and bone height and determine the proper implant size.
3- Patients received a single dose of prophylactic antibiotic one hour before intervention (2 g of amoxicillin or 600 mg of clindamycin if allergic to penicillin). Additionally, they used 0.2% chlorhexidine mouthwash for one minute before the intervention (11).
4- A surgical guide was constructed from the STL files to ensure the ideal implant position.

Surgical procedure

1- Local anesthetic with 40 mg/mL + 0.01 mg/mL of articaine. **Figure (2a)**
2- The crown was cut horizontally at the gingival level from a coronal section of the tooth with a high-speed diamond chamfer bur.
3- The root canal was widened with Gates Glidden burs up to the apical portion to remove all canal contents.
4- Another vertical division was made with a long shank high-speed root resection bur (Komet Dental, Germany) to section the labial and palatal portions of the root (11). **Figure (2b, c)**
5- The palatal part was removed. **Figure (2d)**
6- The labial portion of the root was ground down and chamfered with a diamond bur to locate it below the gingival margin (12).
7- The labial part was reshaped, and the shield width was approximately 1.5–2 mm.
8- The socket was inspected to confirm that all the bone walls were intact. All remnants of granulation tissue were removed with curettes (11).
9- A dentin graft was prepared from the remaining part of the tooth. **Figure (2)**

The dentin graft was prepared as follows:

i. The enamel and cement layers of the extracted teeth were removed with a high-speed dental handpiece. **Figure (3a)**
ii. The teeth were ground with a bone crusher. **Figure (3b)**

iii. The particles were kept in a dentin cleanser solution (20% ethanol + 80% sodium hypochlorite) for 10 min to sterilize the dentin graft. The solution was then absorbed and removed with a gauze pad. **Figure (3c)**

iv. The dentin particles were kept in phosphate-buffered saline (PBS) solution for 3 min to remove the cleaning agent used for sterilization. After 3 min, the excess solution was removed with the help of a gauze pad to ensure that the mineralized dentin graft was ready for socket preservation (13). **Figure (3d)**

10- The surgical guide was seated, the stability of the surgical guide was checked, and special attention was given to the rocking or loose fitting of the guide. Surgical guides were tooth-supported. Figure **(2e)**

11- The implant osteotomy was prepared using a surgical guide to ensure the ideal implant position.

12- The prepared dentin graft was placed around the implant. **Figure (2f)**

13- A healing abutment was placed immediately after the implant placement to help maintain the soft-tissue contours (14). **Figure (2g, h)**

Postsurgical phase

1- A dose of 1 gm amoxicillin and clavulanic acid (Curam 1 gm) was taken twice daily for 5 days postoperatively.

2- Chlorhexidine mouthwash and nonsteroidal anti-inflammatory drugs (ibuprofen 600 mg) were prescribed for 5 days after surgery.

3- After three months, the customized healing abutment was removed, and the ISQ was recorded to start with the prosthetic phase.

4- The prosthesis choice for the final restoration was a screw-retained crown or a cement-retained crown with a restorative margin that can be easily accessed for cement removal (14).

Outcome measures

Clinical indices

The stability of each implant was measured using an Osstell device. RFA uses a compact L-shaped generator installed into the implant or abutment. The transducer is fastened directly to the implant body, it rattles at a constant input and magnitude, beginning at a low frequency and gradually rising in tone until the implant resonates. The ISQ value was measured immediately after implant placement and after three months (15).

Radiographic evaluation

1- All patients were subjected to CBCT scans; the same device did all CBCT scans (immediately and 3 months postoperatively). The authors recorded the distance from the implant shoulder to the bone margin immediately and 3 months after implant placement. The difference between baseline and 3 months following implant placement was calculated as the marginal bone level reduction (MBL) (11).

2- The thickness of the labial cortical plate was studied using cross-sectional sections, with thickness measured postoperatively (m1) and after 3 months (m2) in the labio-palatal direction in the middle of the implant. The difference between baseline and 3 months following implant placement was calculated as the reduction in labial plate thickness (m1-m2) (10).

3- The density of bone around the implant 3mm from the crest and 6 mm from the crest mesially and distally was recorded via CBCT in the same four positions around the implant, and the mean bone density was recorded immediately and 3 months after the placement of the implants.

Statistical analysis

Statistical analysis of the data

The data were analyzed using the IBM SPSS software package version 20.0**.** The qualitative data are presented as numbers and percentages. The Shapiro-Wilk test verified the normality of the distribution. Quantitative data are presented as the range (minimum and maximum), mean, standard deviation, median, and interquartile range (IQR). The significance of the obtained results was judged at the 5% level.

The tests used were

1 - Chi-square test

For categorical variables, comparisons were made between different groups.

2 - Fisher's exact correction

The chi-square test was used when more than 20% of the cells had an expected count of less than 5.

RESULTS

Regarding immediate implant placement's stability via the socket shield technique and autogenous dentin graft. The mean primary stability was 55.09, with a standard deviation of 5.58, while the mean secondary stability after 3 months was significantly increased to 69.91, with a standard deviation of 4.28. **Table (1), Figure (4)**

For the changes in the thickness of the labial cortical plate. The mean change was 0.35, with a standard deviation of 0.12. For the marginal bone level change. The mean change was 0.19, with a standard deviation of 0.09. **Table (2), Figure (5)**

Regarding the mean bone density immediately after surgery, the mean was 1154 with a standard deviation of 102.5, while after 3 months, the mean significantly increased to 1338.4 with a standard deviation of 93.39. **Table (3), Figure (6)**

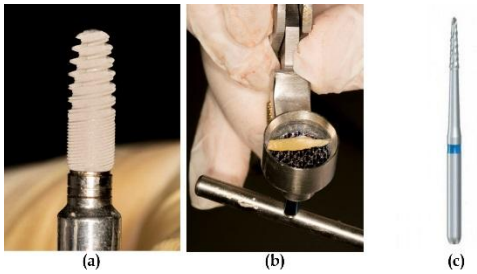

Figure (1): (a) C-Tech Implant. (b) Bone Crusher. (c) Long shank high-speed carbide bur.

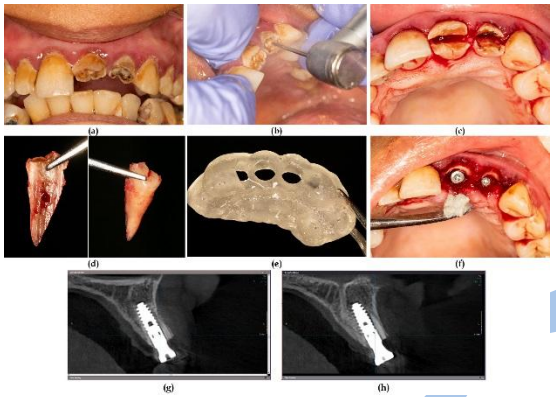

Figure (2): (a) Preoperative image. (b), (c) Socket shield preparation. (d) Removal of the palatal portion of the tooth. (e) Surgical guide printed. (f) Placement of the dentin graft after implant placement. (g), (h) cross-sectional view of cone-beam computed tomography images.

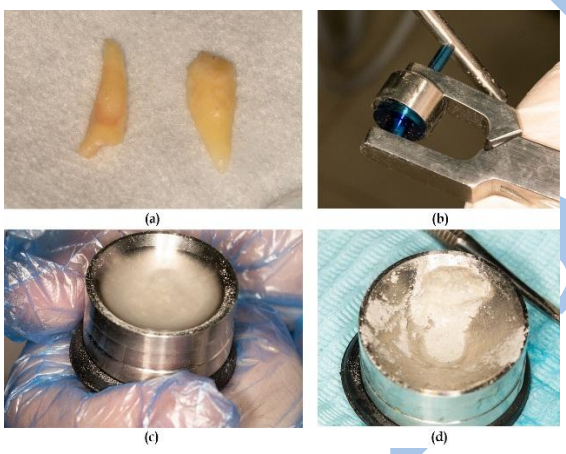

Figure (3): (a) Enamel and cementum removal. (b) Crushing of the dentin. (c) Dentin processing. (d) Dentin graft.

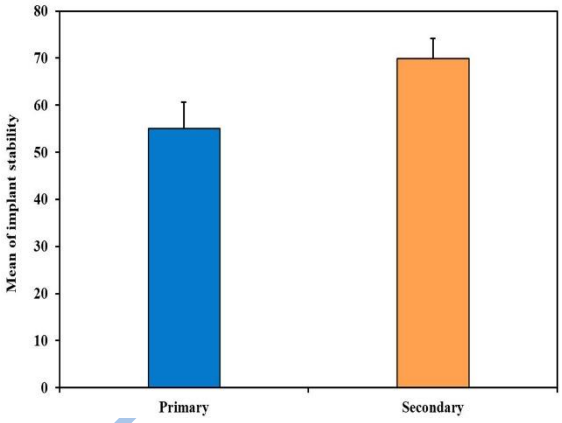

Figure (4): Evaluation of implant stability of immediate implant placement with SST and autogenous dentin graft.

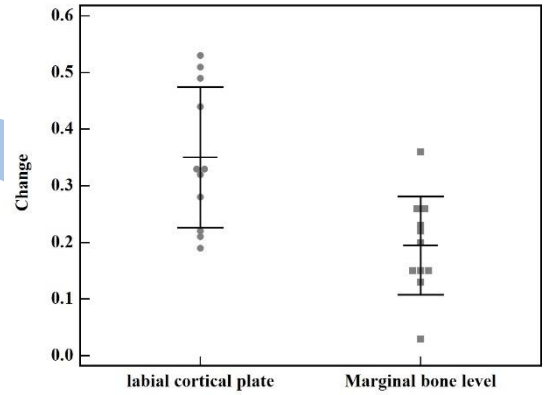

Figure (5): Evaluation of the thickness of the labial cortical plate and the marginal bone level of immediate implant placement with SST and autogenous dentin graft.

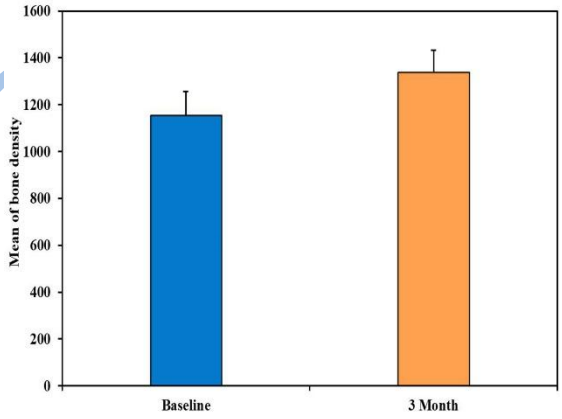

Figure (6): Evaluation of bone density of immediate implant placement with SST and autogenous dentin graft.

Table (1): Evaluation of implant stability of immediate implant placement with SST and autogenous dentin graft.

Implant Stability	IMM (n = 11)
Primary	
Min. – Max.	49.0 – 66.0
Mean ± SD.	55.09 ± 5.58
Median (IQR)	53.0(51.5 – 56.0)
Secondary	
Min. – Max.	64.0 – 78.0
Mean ± SD.	69.91 ± 4.28
Median (IQR)	69.0(67.0 – 71.0)

IQR: Inter quartile range SD: Standard deviation

Table (2): Evaluation of the thickness of the labial cortical plate and the marginal bone level of immediate implant placement with SST and autogenous dentin graft.

Change	IMM (n = 11)
labial cortical plate	
Min. – Max.	0.19 – 0.53
Mean ± SD.	0.35 ± 0.12
Median (IQR)	0.33(0.25 – 0.47)
Marginal bone level	
Min. – Max.	0.03 – 0.36
Mean ± SD.	0.19 ± 0.09
Median (IQR)	0.20(0.15 – 0.25)

IQR: Inter quartile range SD: Standard deviation

Table (3): Evaluation of bone density of immediate implant placement with SST and autogenous dentin graft.

Bone density	IMM (n = 11)
Baseline	
Min. – Max.	1009.0 – 1310.2
Mean ± SD.	1154.0 ± 102.5
Median (IQR)	1156.0(1074.5 – 1242.0)
3 Month	
Min. – Max.	1146.0 – 1494.0
Mean ± SD.	1338.4 ± 93.39
Median (IQR)	1345.0(1306.0 – 1406.0)

IQR: Inter quartile range SD: Standard deviation

DISCUSSION

Resorption of the buccal bundle bone after tooth extraction and implant placement can cause significant complications, often resulting in extremely negative cosmetic impacts. Hence, grafting procedures are commonly carried out to minimize the loss of bundle bone. Studies have shown that bundle bone resorption is minimal if the dental root remains in the alveolar process (16).

It has been confirmed that tooth dentin grafts can be used as bone graft materials for many dental procedures (17), however, the disadvantage is that there is not enough material for the required procedure.

Dentin hydroxyapatite (about 70% of the dentin's weight volume) is constructed with low-crystalline calcium phosphate, unlike enamel hydroxyapatite. This allows osteoclasts to destroy it and promote successful bone remodeling (18).

This feature is comparable to bone tissue, primarily low-crystalline calcium phosphate, although it is necessary for alveolar ridge renewal and osteoconductive ability. In addition to hydroxyapatite, there are three biological calcium phosphates: tricalcium phosphate, octacalcium phosphate, and amorphous calcium phosphate (19).

The current study was directed to evaluate clinically and radiographically immediately placed implants with SST and autogenous dentin grafts.

In the current study, the mean implant stability quotient (ISQ) value for the immediate placement group significantly increased after 3 months, and all the implants were loaded after 3 months. These findings agree with those of Turkyilmaz and McGlumphy (20), who studied 170 successful implants with increased implant stability from 6 to 12 months. The implants were functionally loaded 3 months after placement.

Kim et al. (21) concluded that successfully placed implants had increased ISQ values and that RFA is appropriate for predicting implant success/failure. These findings agree with the results of this study, as there were no cases of implant failure during the follow-up period.

In our study, the mean of the change in the marginal bone level was 0.19 mm in the immediate group, all the implants successfully maintained osseointegration, and similar results were observed by Siormpas et al. (22) in their study as they detected good crestal bone stability with mean crestal bone loss on the mesial and distal aspects of the implants assessed to be 0.18 ± 0.09 mm and 0.21 ± 0.09 mm, respectively and all the implants effectively maintained osseointegration. Similar results were obtained in the retrospective study by Abitbol et al. (23) at 1 year of follow-up, where no signs of bone loss were present at the alveolar crest. In addition, the results obtained by Barakat et al. (24), in a randomized controlled trial compared conventional immediate implant placement and SST, concluded that the mean horizontal and vertical bone loss value in SST was estimated by 0.09 ± 0.03 mm and 0.43 ± 0.23 mm in contradiction of 0.33 ± 0.14 mm and 1.56 ± 0.77 mm in the conventional implantation.

Bäumer et al. (25) concluded that immediate dental implant placement with the socket-shield technique

reduces surgical procedure invasiveness and is associated with high aesthetic outcomes and efficient preservation of facial tissue contours. These findings agree with the results of our study.

Bramanti et al. (26) assessed the marginal bone level MBL in immediate implants with and without socket-shield preservation at three years of follow-up. They concluded that the socket-shield technique can be used as a surgical technique for dental implant placement and is associated with better aesthetic outcomes. These findings support the results of our study. This preservation of the therapy over time can be attributed to the maintenance of vascular support by periodontal ligament preservation.

In our study, the mean change in the thickness of labial bone after 3 months was 0.35 in the immediate group. Similar results were reported by Sun et al. (27) in a randomized controlled trial who observed higher buccal plate width (1.15 ± 0.27 mm) and buccal plate height (2.59 ± 0.21 mm) values in the SST group in comparison with the control group (bone plate width = 0.83 ± 0.13 mm and bone plate height = 1.82 ± 0.18 mm) 6 months after implant placement. In a study by Xu et al. (28), the labial bone thickness after 1 year was observed to be 2.90 ± 0.64 mm in the SST group and 2.51 ± 0.69 mm with the conventional technique. The results of these studies confirm that the SST cannot completely avoid labial bone plate resorption, but it can efficiently reduce it. This decreased bone loss in the SST can be justified by the decreased structural destruction of the extraction sockets and maintenance of the vascular supply after the preservation of the PDL of the socket shield.

Immediate implant placement with SST and autogenous dentin grafts has an advantage in decreasing the treatment time and the number of surgical interventions (29).

Our study significantly increased the mean bone density for immediate implant placement with the socket shield technique and autogenous dentin graft. This increase demonstrated successful bone formation and mineralization, which increased implant primary stability and osteointegration, which agrees with the study of Ivanova (30).

The limitation of this study is the short observation period, which was due to the secondary implant stability measurements being at the recommended value for implant loading, especially as MBL was measured only at 3 months.

CONCLUSION

Immediate implant placement via the socket shield technique and dentin graft significantly improved implant stability after 3 months. Radiographically, there were clinically successful results of the change in labial bone thickness and marginal bone level reduction. The mean bone density around the implants significantly increased after 3 months.

With a larger sample size, additional research is needed on immediate implant placement with the socket shield technique and using different bone grafts compared to dentin grafts for ridge preservation.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

FUNDING STATEMENT

The authors received no specific funding for this work.

ACKNOWLEDGMENTS

Not applicable.

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