# Radiographic Alternations in Alveolar Bone Dimensions Following Socket Preservation using Two Bone Substitutes

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**Abstract**

Socket preservation is important after tooth extraction. This study evaluates radiographic alternations in alveolar bone dimensions following socket preservation using two bone substitutes: cockle shells and beta-tri calcium phosphate bone (β-TCP)

The sample comprised 18 healthy patients (mean age =26.8 years) and 36 bilateral maxillary incisors or premolars were extracted traumatically. Fresh extraction sockets were randomly allocated into groups. In group Cks,18 sockets were treated with cockle-shell bone substitute. In group Tcp,18 sockets were grafted with β-TCP. Cone beam computed tomograms were produced after tooth extraction and nine months post-surgery. The distances (mm) were measured between the alveolar bone apex and buccal and palatal crests. The cross-sectional area ($mm^2$) of extraction sites was calculated. Statistical analysis was performed to assess differences between groups.

At nine months, the buccal and palatal wall heights decreased significantly in both groups. The cross-sectional area decreased significantly by 25% and 27% in groups Cks and Tcp, respectively. There were no significant differences between groups in the diminution of the alveolar ridge at nine months.

Using β-TCP and cockle-shell bone substitutes in grafting extraction sockets decreased alveolar bone resorption but did not prevent it.

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## Introduction

Sufficient alveolar bone volume, thickness, and height are considered main prerequisites for successful dental implant procedures.[1] Progressive alveolar bone loss after tooth extraction must be taken into consideration because additional treatment modalities are essential for reducing the effects of these ventual changes.[2] Studies on human and animal experiments reveal that fresh extraction sockets that were grafted with bone biomaterials demonstrate less vertical and horizontal contraction in the bone crest compared to non-grafted sites.[3] Autogenous bone grafts, xenografts, and bone substitutes have been used as bone grafting materials in Alveolar ridge preservation procedures.[4]

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Beta tricalcium phosphate (β-TCP) is a synthetic alloplastic material that has been used in orthopedic and other surgical specialties for almost 30 years. It is commercially available for the reconstruction of bone defects in maxillofacial and periodontal surgeries.[5] β-TCP is a suitable bone substitute that provides a biodegradable scaffold for the ingrowth of vascular and cellular components within the extraction socket to form new bone of acceptable quality and quantity.[6] However, the search for new bone substitutes has led to the use of bioceramic materials that are synthesized from natural materials, such as egg shells,[7] cuttlefish bone,[8] coral derivatives, and more recently, cockle shells.[9] Zakaria compared the mineral composition of clam shells, cockle shells, and corals. The results supported using cockle and clam shells as biomaterials for the management of bone defects.[9] Laboratory assessments and animal trials provide a strong basis for the use of cockle shells

(*Anadaragranosa*) and other selected Mollusca shells (including Bivalvia species) as a potential material for bone tissue engineering.[10,11]

The aim of this study is to compare the use of cockle shells and β-tricalcium phosphate as bone graft substitutes in socket preservation therapy of the maxillary non-molar region. The study also evaluates the radiographic dimensional alterations in the alveolar bone tissues of the preserved sockets.

## Materials and methods

A prospective, comparative, randomized clinical trial study was conducted. The study was approved by the Institutional Ethics Committee at Damascus University. Patients referred to the Department of Periodontology at the Faculty of Dentistry of Damascus University were invited to participate. Ultimately, 18 subjects (mean age= 26.8 years) were included using the following criteria: nonsmokers, unremarkable medical histories, and scheduled to have bilateral extractions of teeth in the non-molar region due to chronic periodontal disease. Participants gave written consent after being informed about the nature of the treatment procedures and possible risks.

A split mouth study design was implemented, and a total of 36 teeth from the maxillary region extending from the left second premolar to the right second premolar were randomly (coin toss) allocated into two groups. Group Cks comprised 18 extraction sockets treated with cockle shell bone substitute. The other 18 extraction sockets in group Tcp were filled with beta-tri calcium phosphate (β-TCP).

## Preparation of cockle shell bone substitute

The cockle shell bone substitute was prepared and fabricated according to the protocol described by Zakaria.[9]

## Surgical procedure

After the administration of local anesthesia (2% Xylocaine with 1:80,000 adrenaline), a flapless atraumatic extraction of the selected tooth was performed. The great care was taken to protect the buccal and palatal bone plates. Curettes were used to gently remove the soft tissues in the socket. Subsequently, randomization was performed by coin toss to maintain a balanced distribution between study groups. Sockets in group Cks were filled with granules of synthetic cockle–shell bone substitute up to the crest level. The graft material was stabilized with a mattress suture. The same surgical steps were implemented ingroup Tcp except that the sockets were filled with β-TCP granules (Sorbone® Meta-Biomed, Seoul, Korea).

Systematic antibiotic (amoxicillin 500 mg; Amoxi® Unipharma, Damascus, Syria) was administered three times per day during the first week post-surgery. Additionally, patients were asked to avoid brushing during the first 2 weeks after surgery and to rinse twice daily with a solution of 0.12% chlorhexidine (Biofresh® Unipharma, Damascus, Syria). Sutures were removed after 10 days.

## Radiographic assessment

Cone beam computed tomograms (CBCT) were produced immediately after tooth extraction and socket grafting and repeated at 9 months after grafting. Radiographic assessment was done according to the protocol reported by Araújo.[12] In brief, data generated by CBCT were transferred to specific volumetric imaging software (Ez3D-plus® Ewoo-soft, Seoul, Korea)to perform image analyses. A CBCT scan image representing the buccal-palatal plane of the extraction socket was produced. Measurements of the following dimensions were carried out (Figure 1). The heights of the buccal (Bw) and palatal (Pw) bone walls were calculated by measuring the vertical distance between the apical extension of the alveolar ridge and Bw and Pw. Next, the cross-sectional area was measured (area $mm^2$) using the cursor after outlining the profile of the alveolar process, including the peripheral portion of the graft. At nine months post-surgery, a new CBCT examination was performed in an identical manner, and the measurements were repeated.

## Statistical analysis

The collected data were statistically analyzed using SPSS (version 21, IBM Corp, NY, USA). The Shapiro-Wilk test was used to determine if the data is normally distributed. In the radiographic assessments, the data for bone plates and section areas were normally distributed. Mean values and standard deviations (SD) were calculated for each of the studied dimensions in the two treatment groups. A paired t-test was used to assess intragroup dimensional changes. The independent t-test was used for intergroup comparisons, and 95% confidence intervals were calculated. The results were considered statistically significant at the level of *P*<0.05.

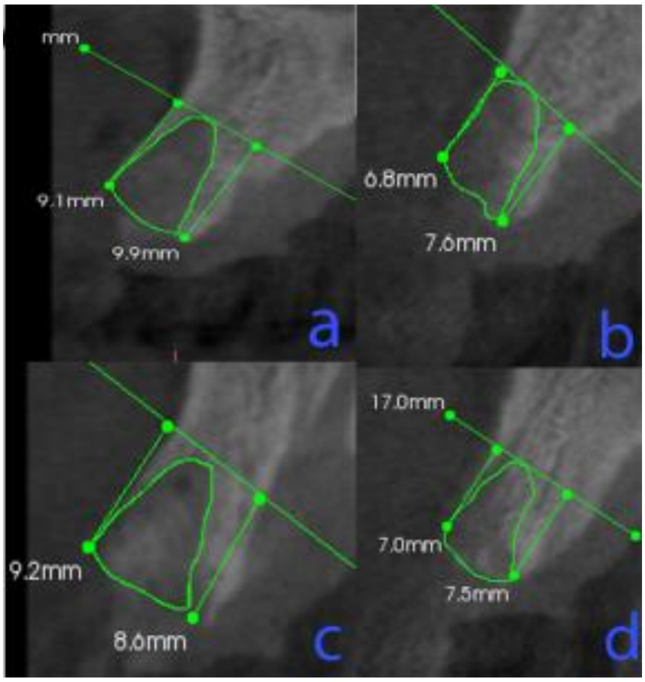


**Figure 1.** Measurements of Palatal Wall Height, Buccal Wall Height, and Cross Sectional Area: a) Cks Group at Base Time. b) Cks Group after 9 Months. c, d) TCP Group At Baseline And 9 Months, Respectively.

## Results

### Radiographic measurements

**Buccal and palatal bone walls**. The data in table 1 show that at baseline in group Cks, the heights of the buccal and palatal bone walls were 7.85±2.03 mm and 8.71±1.3mm, respectively. The corresponding dimensions in group Tcp were 7.32±1.2 mm (buccal) and 8.37±1.4 mm (palatal). There was no statistically significant difference between groups with respect to the height of the socket walls.

At nine months post-surgery, a noticeable reduction was observed in the buccal bone wall (Bw) among both study groups (Table 1). The height Bw as 6.33±0.9 mm in group Cks and 5.92±1.2 mm in group Tcp. In other words, during a healing period of nine months the height B deceased by 24%in group Cks and 23% in group Tcp. These reductions were statistically significant (Cks: *P*=0.001; Tcp: *P*=0.003). Nonetheless, there was no difference between the two treatment groups with respect to decrease of the Bw height (Table 2).

| Bone dimension* | Groups | Baseline | 9 months | *P* value |
|---|---|---|---|---|
| Buccal wall height (B height) | β-TCP | 7.32±1.2 | 5.92±1.2 | 0.003 |
| | Cks | 7.85±2.03 | 6.33±0.9 | 0.001 |
| Palatal wall height (P height) | β-TCP | 8.37±1.4 | 7.17±1.1 | 0.001 |
| | Cks | 8.71±1.3 | 7.34±0.85 | 0.0082 |
| Cross sectional area (CSA) | β-TCP | 70.33± 7.01 | 52.91±7.9 | 0.00091 |
| | Cks | 68.72±10.3 | 50.3±9.1 | 0.001 |

**Table 1.** Measurements of the Examined Radiographic Bone Dimensions at Baseline and 9 Months Post-Surgery. *Mean ±SD in mm.

| Bone dimension* | Cks | B-TCP | *P* value |
|---|---|---|---|
| ΔB height | -1.52±0.53 | -1.4±0.9 | 0.82 |
| ΔP height | -1.37±0.7 | -1.2±0.8 | 0.73 |
| ΔCSA | -17.42±2.3 | -18.42±1.7 | 0.28 |

**Table 2.** The Mean Differences in Bone Dimensions Between Cksand β-TCP Groups at 9 Months. *Mean ±SD in mm

Similarly, after 9 months of healing, the palatal bone wall (P) was 7.34±0.85 mm in group Cks and 7.17±1.1mm in group Tcp. In other words, between baseline and 9 months, the Pw) height decreased by about 16% in both study groups. These reductions were statistically significant (*P*<0.001). However, there was no difference between the two treatment groups with respect to decrease of the Pw height.

### Cross-sectional area

At baseline, there was no statistically significant difference between groups. As shown in table (1) the cross-sectional area (CSA) of the alveolar process at the fresh extraction site was 68.72±10.3 $mm^2$ (group Cks) and 70.33±7.01 $mm^2$ (group Tcp). At 9 months, the CSA in group

Cks decreased to 50.3±9.1 $mm^2$ (a reduction of 27%), while the corresponding decrease in group Tcp was 52±7.9 $mm^2$ (a reduction of 25%). The difference in alveolar ridge diminution between groups was not statistically significant (Table 2).

## Discussion

The present study revealed similar dimensional alterations in extraction sockets treated with either cockle shells or TCP bone substitutes. Healing during 9 months following socket preservation resulted in a decrease in the dimensions of the bone tissues of the extraction sites. There were also similar reductions in the buccal bone walls and palatal walls. Further examination indicated that the decrease in the cross-sectional area after 9 months was nearly equal in both treatment modalities.

The amount of crestal bone resorption reported in this study (group Cks: buccal=1.52 mm, palatal = 1.37 mm; and group Tcp: buccal= 1.38 mm, palatal = 1.2 mm) is compatible with the findings of Jung et al.[13] However, the dimensional changes in the buccal bone wall in this study were not in accordance with the results of Nevins et al.,[14] who reported that the buccal bone wall lost 5.24 mm of its original dimension. Araujo et al. (2014) reported a loss of 3.6-4.2 mm.[12] The conflicting data could be due to the dissimilar characteristics of the extraction site locations (upper/lower, maxilla/mandible) and the degree of tissue loss prior to extraction.

The cross-sectional area of the control ridge was significantly reduced by about 27% in group Cks and 25% in group Tcp between baseline and 9 months. Notably, the amount of ridge alteration in the present sample was not considerably different between the post-extraction sites in both groups. This finding is in disagreement with data from Nevins et al.[14] and Barone et al.[15] The reason for this discrepancy is the different types of grafting materials used for socket preservation. In addition, sites with smaller or larger post-extraction sockets may respond to tooth loss with varying amounts of tissue reduction.

Overall, the ability of β-TCP to achieve alveolar preservation in our study is in line with previous studies. Mardas et al.[16] conducted a radiographic study and found no differences between the use of β-TCP and bovine bone mineral for socket preservation. Similarly, Brkovic et al. (2012) studied 20 patients allocated into two groups: one receiving β-TCP and membrane and the other receiving β-TCP alone with a 9-month follow up. They reported good socket preservation in both groups, although it was better in the group with the membrane.[17] Munoz-Corcuera et al. (2015) evaluated the post-extraction application of β-TCP in 16 premolar sockets and analyzed bone samples harvested six months later during implant placement surgery. After a histological study, they concluded that β-TCP is capable of achieving preservation of the alveolar bone and also helps the formation of new bone in the socket.[18]

It is of great importance to highlight the fact that a direct comparison between our study and the aforementioned studies is not as straight forward as one might expect because of the differences in study design, follow up period, type of extraction sockets, and radiographic means of measurements. To the best of our knowledge, this is the first report to examine the use of cockle shells as a bone substitute for socket preservation. Cockle shell bone substitute was fabricated according to the protocol described by Zakaria et al. (2004). The advantage of this synthesis method is that it increases the homogeneity of the decomposition at the nano level and allows for the easy preparation of nanocrystals of comparatively equal sizes. Additionally, it was found to contain no detectable levels of toxic elements. Moreover, the synthesis process is environmentally friendly, utilizes naturally available cockle shells, and could be scaled up for industrial production. It thus offers the possibility for exploration in numerous medical applications.[9]

The use of cockle shells as a bone substitute yielded nearly the same results as β-TCP in socket preservation. This finding could be explained in the light of the properties and characteristics of cockle shells that were obtained from previous animal reports. Firstly, cockle shells have similar mineral and physiochemical characteristics and are predominantly the aragonite form of calcium carbonate. The biogenic material exhibits unique properties, such as higher density than that of calcite. This make it biocompatible and provides a strong basis for its use as a potential bone tissue engineering material, as well as an interesting candidate for biomineralization studies.[19]

Secondly, cockle shells are an osteo condutive biomaterial that acts as a scaffold for osteoblastic apposition and is gradually resorbed and replaced by newly formed bone.[11] Hence, the biodegradability of cockle shells compared to other bone graft materials makes it a useful material for certain grafting procedures, including socket preservation and other periodontal bone regeneration therapies. Lastly, cockle shells are cheaper than other materials and are abundantly available worldwide, making them a good choice as a bone replacement material.[20]

This study had some limitations. The composition of the newly formed tissue in the extraction site is unknown since no attempt was made to analyze it. Furthermore, the sample size was somewhat small due to financial restrictions.

## Conclusions

Within the limits of this study, it can be concluded that grafting of extraction sockets with β-TCP or cockle-shell-derived bone substitutes markedly counteracted the decline in the alveolar ridge bone but did not prevent bone resorption. Cockle shells might have properties and characteristics that make them a suitable bone substitute biomaterial. Nevertheless, further research is still needed to explore its full potential in dental applications.

## Declaration of Interest

The authors report no conflict of interest and the article is not funded or supported by any research grant.

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