Original Article

Socket preservation with medical grade calcium sulfate hemihydrate: a radiographic study evaluating the dimensional changes of the alveolar ridge

Tian Niang Chain [1], Jyothi L [2], Jeevanand Deshmukh [3], Asif K [4], Sindhura H [5], Revu Das S. D [6]

[1] Consultant Periodontist, Dental health care, 33 Kasia road, Civil lines, Betiahata, Gorakhpur, Uttar Pradesh, Pin Number: 273-001
[2] Consultant Periodontist, Shree Tirumala Denral Specialities, Super market circle, Petla burz, Raichur, Karnataka, Pin Number: 584-101
[3] Professor & Head, Department of Periodontology, Navodaya Dental College & Hospital Raichur, Karnataka Pin Number: 584-103
[4] Professor, Department of Periodontology, Navodaya Dental College & Hospital Raichur, Karnataka, Pin Number: 584-103
[5] Reader, Department of Periodontology, Navodaya Dental College & Hospital Raichur, Karnataka, Pin Number: 584-103
[6] Assistant professor, Department of Periodontology, Sri Sankara Dental College & Hospital, Akathumuri, Kerala, Pin Number: 695-318

Abstract

Background and Aim: Medical grade calcium sulfate hemihydrate (MGCSH) is used as a bone graft material for socket preservation. This study aimed to evaluate the changes in bone width and height after tooth extraction and socket preservation with MGCSH using cone-beam computed tomography (CBCT).

Materials and Methods: This study evaluated 17 systemically healthy patients over a 1-year period. The patients were selected among those presenting to an outpatient department. CBCT was taken with a radiographic stent and extraction was performed; socket dimensions were measured. Socket preservation was performed using MGCSH. After 3 months, another CBCT was taken, and socket dimensions were measured. The change in socket dimensions was quantified by comparing the preoperative and postoperative radiographs. Comparisons were made by paired t test.

Results: At 3 mm from the initial ridge crest, the mean bone width was 6.24 ± 1.73 before and 4.74 ± 1.91 mm after 3 months; this difference was statistically significant (P<0.001). At 6 mm, the mean bone width was 7.05 ± 1.50 before and 5.49 ± 1.82 mm after 3 months; this difference was also statistically significant (P< 0.001). At 9 mm, the mean bone width was 7.46 ± 2.16 mm before and 5.71 ± 1.75 mm after 3 months; this difference was statistically significant (P<0.001). The initial mean height was 12.16 ± 2.21mm, which changed to 12.99 ± 2.69 mm at 3 months, with no significant difference (P=0.22).

Conclusion: Socket preservation with MGCSH caused a significant change in ridge width, but not in ridge height.

Key Words: Calcium Sulfate; Socket preservation; Dental implants; Tooth Extraction

Corresponding author: Revu Das S. D, Assistant professor, Department of Periodontology, Sri Sankara Dental College & Hospital, Akathumuri, Kerala, Pin Number: 695-318

revudas75@gmail.com

Received: 10March 2022
Accepted: 7 July 2022

➢ **Cite this article as:** Tian Niang Chain, Jyothi L, Jeevanand Deshmukh, Asif K , Sindhura H, Revu Das S. Socket preservation with medical grade calcium sulfate hemihydrate: a radiographic study evaluating the dimensional changes of the alveolar. ridge. J Iran Dent Assoc. 2022; 34(1-2):19-26. doi: 10.34172/jida.A-10-1-978

Introduction

Tooth extraction is a common dental procedure, indicated when an irreparable damage to the tooth and/or its supporting structures has taken place. [1] A consequent loss in height and width of the alveolar ridge always takes place after extraction. Changes in alveolar bone dimensions after extraction greatly alter treatment decisions of any restorative and prosthetic rehabilitation especially with dental implants. [2]

Guided bone regeneration was documented to face the problems of ridge deficiency but has shortcomings such as high cost, long healing period, invasive nature, and being technique-dependent. Total soft tissue coverage is difficult to obtain, compromising the cosmetic results. [3] Immediate implant placement was also suggested to preserve the alveolar ridge contour but the results were not favourable with respect to bone preservation. [4] To overcome these problems, socket preservation was developed as a technique to preserve the alveolar ridge dimensions. [5]

Autogenous bone grafting and bone substitutes such as allogenic, alloplastic, and xenogeneic materials have been used for socket preservation, each with their own set of benefits and drawbacks. [6]

Medical grade calcium sulfate hemihydrate (MGCSH) has been used for socket preservation as well. [5] It is a readily available, biocompatible, biodegradable, inexpensive, and osteoconductive bone graft material. [6, 7] It becomes osteogenic in presence of bone and/or periosteum due to its osteoconductive nature. [6] Within 12 weeks, degradation of calcium sulfate causes a localized drop in pH, which is sufficient to demineralize the adjacent socket walls and release bone morphogenetic proteins 2 and 7, and transforming growth factor-beta as well as platelet-derived growth factor. [8] It was noticed that there was greater bone formation in defects which were grafted with a composite of allograft and calcium sulfate versus allograft alone. [9-11] Periodontal defect repair, sinus augmentation, and extraction socket preservation for implant placement are all possible with MGCSH. [5]

Various radiographic modalities such as bitewing, periapical, and panoramic radiography are used to plan implant placement. [12] However, they have some drawbacks, such as patient positioning and difficult linear measurement of mesial and distal dimensions due to their two-dimensional nature. [2, 3] To overcome such limitations, cone-beam computed tomography (CBCT) was introduced. [3] CBCT acts an ideal radiographic tool with high accuracy and resolution and lower radiation dose than computed tomography. [12]

This study aimed to evaluate the changes in bone width and height after tooth extraction and socket preservation with MGCSH using CBCT.

Materials and Methods

The study participants were selected among those presenting to the outpatient oral medicine and periodontology department. A total of 17 single-rooted teeth requiring extraction were selected for this study.

The sample size was calculated to be 17 according to a study by Lauren et al, assuming the effect size of 0.75, alpha=0.05, and 90% power using G power software v.3.1.9.2.

The study included systemically stable patients aged 20 to 45 years who had an extraction socket with a four-wall design and an intact buccal cortical plate. The exclusion criteria were vertical and or severe horizontal bone loss, smokers, pregnant and lactating women, and medically compromised patients.

The participants were briefed about the study, need for surgery, and its possible outcome, and written informed consent was obtained from them. The Ethical Committee also granted permission to proceed.

The teeth that required extraction were confirmed through clinical and radiographic examination. There was a minimum of 12-week interval between the first and second CBCT. Impressions were made and cast was poured for each patient. A customized radiographic stent was fabricated on the diagnostic cast. The stent was used to stabilize the non-restorable or

hopeless tooth as well as the neighbouring teeth.

Clear acrylic resin was used to fabricate the stent with seven holes: one in the occlusal plane, three in the buccal, and three in the palatal/lingual aspect, at 3, 6, and 9 mm apical to the midpoint of the gingival margin of the tooth to be extracted. As landmarks for radiographic measurements, these holes were filled with radiopaque gutta percha.

The patient was asked to wear the stent during CBCT scanning according to the protocol. A hard copy of the CBCT scans was received to make the radiographic measurements.

For the ridge width, the CBCT scans were analyzed at three points along the radiopaque markers: 3, 6, and 9 mm apical to the midpoint of the gingival margin of the tooth to be extracted. The height measurement was done with the help of an occlusal marker coronal to the initial crest. The actual ridge width was calculated by subtracting the combined dimensions of the buccal marker to buccal alveolar plate measurements and the lingual marker to lingual alveolar plate measurements from the buccal to lingual marker distance at each step. The vertical distance between the occlusal marker and the initial crest was also measured.

Preoperative CBCT was taken (Figure 1). The same clinician performed all the surgical procedures. The anesthetic technique was standardized for all patients. To induce local anesthesia, 2% lidocaine was used along with 1: 10,000 epinephrine.

To access both the labial and palatal/lingual parts of the alveolar ridge, a full thickness mucoperiosteal flap was elevated. The facial flap was reflected while retaining the interproximal papillae. The tooth was lifted, and an atraumatic extraction was performed using forceps. The tooth was sectioned in the socket if necessary for atraumatic extraction while retaining all the socket walls. The extraction socket was curetted to remove all the soft tissue accumulated in the extraction socket during extraction. MGCSH was grafted in the socket with three different consistencies: in the apical part, prehardened MGCSH was grafted; in the middle portion, MGCSH was compacted with dry gauge; and in the coronal portion, a fast set solution was used to quickly achieve the toughest consistency possible. The medical grade calcium sulfate hemihydrate itself acts as a barrier membrane after setting. [19] Suturing was performed. The sutures were removed after 7 days.

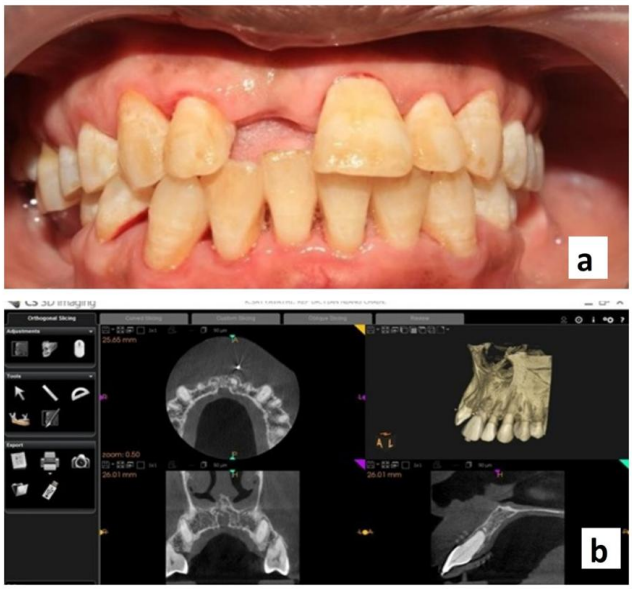

Figure 1. (a) Preoperative clinical view (b) Preoperative CBCT

The patients received verbal and written postoperative instructions. The surgeon prescribed ibuprofen, 600 mg every 8 hours for the first 24 hours and Si Opus Sit/if needed thereafter for 1 week as pain medication.

At 3 months after graft placement, the previous stent was used and CBCT was taken (Figure 2). Postoperative measurements were made in the same way as the preoperative measurements were made.

The changes in horizontal ridge width at the 3, 6, and 9 mm radiopaque markers were calculated by subtracting the post-extraction values from the pre-extraction values. Subtracting the preoperative vertical distance values from the postoperative vertical distance values yielded the magnitude of change in the coronal ridge height.

A Performa structure was used to collect data. Data were entered into a Microsoft Excel

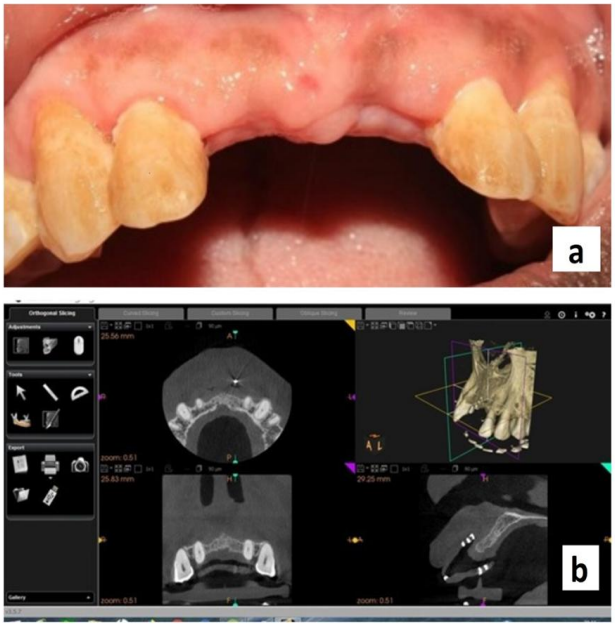

Figure 2. (a) Postoperative clinical view at 3 months, (b) postoperative CBCT at 3 months

spreadsheet, and statistical analysis was performed using SPSS version 16.0 (SPSS Inc., IL, USA). The graphs and tables were created using Microsoft Word and Excel. The percentage and frequency of qualitative data were reported. The mean and standard deviation values were used to express quantitative results. To decide whether the mean difference between the preoperative and postoperative CBCT measurements is important, the paired t-test was used to compare the mean values between the two groups. Each variable's descriptive statistics were described in terms of mean, standard deviation, and standard error of the mean. In this analysis, descriptive and inferential statistical analyses were used. Level of statistical significance was set at 0.05.

Results

A total of 17 patients with single rooted teeth in need for extraction were included in this study. The preoperative and the postoperative socket dimensions along with the change in socket dimensions were assessed. During the course of the study, wound healing was uneventful, i.e., the extraction site did not show any sign of inflammation. No patients showed adverse reactions to the bone graft. None of the selected patients dropped out before the completion of the study.

The mean age was 34.90 ± 10.525 years in males (range 20 to 44 years). The mean age was 43.00 ± 2.582 years in females (range 38 to 45 years). The study consisted of 10 males and 7 females.

Table 1 presents socket dimensions measured on preoperative CBCT scans. At 3 mm from the gingival margin, the mean width was 6.24 ± 1.73 mm. After extraction and socket preservation protocol at 3 months, the mean width decreased to 4.74 ± 1.91 mm, which was statistically significant (P<0.001).

At 6 mm below the gingival margin, the mean width was 7.05 ± 1.50 mm at baseline which significantly decreased to 5.49 ± 1.82 mm at 3 months (P< 0.001).

At 9 mm below the gingival margin, the mean width was 7.46 ± 2.16 mm at baseline which significantly decreased to 5.71 ± 1.75 mm at 3 months (P<0.001).

The initial mean height of the socket was 12.16 ± 2.21 mm. The mean height was preserved at 12.99 ± 2.69 mm at 3 months after extraction and socket preservation, which indicated a statistically insignificant change in socket height (P=0.22).

Discussion

Traumatic tooth extraction can cause morphological alterations in the alveolar process, both vertically and in the width of the residual bone. [13] As a consequence, to preserve the hard and soft tissue of the alveolar ridge after extraction, socket preservation is needed. [14]

In the present study, 17 patients were selected including 10 males and 7 females in the age range of 20 to 45 years. The patients had single-rooted teeth which were indicated for extraction. These included 3 central incisors, 6 lateral incisors, 2 canine teeth, 1 first premolar, and 5 second premolar teeth.

Calcium sulfate pellets alone enabled superior bone regeneration than when mixed with grafts, such as autograft, demineralized bone matrix, bone marrow aspirate, morselized allograft or a

Table 1. Comparison of preopertaive and postopertaive scores using paired t test

		Minimum	Maximum	Mean	SD	Mean diff	P value
Width at 3 mm	Preoperative	3.00	8.30	6.24	1.73	1.49	0.00*
	Postoperative	1.70	8.00	4.74	1.91		
Width at 6 mm	Preoperative	4.30	9.00	7.05	1.50	1.56	0.00*
	Postoperative	3.00	8.50	5.49	1.82		
Width at 9 mm	Preoperative	4.70	11.50	7.46	2.16	1.75	0.001*
	Postoperative	3.40	9.00	5.71	1.75		
Height	Preoperative	9.50	16.10	12.16	2.21	-0.83	0.22
	Postoperative	8.70	17.70	12.99	2.69		

SD = Standard deviation
Mean diff. = Mean difference
P<0.05 was considered statistically significant whereas P<0.001 was considered highly significant.
* = Statistically significant

combination of them. [15] It also has the potential to improve angiogenesis. [16] After implanting calcium sulfate pellets in sheep femora, calcium sulfate served better than a simple space filler, indicating that it may accelerate healing through pH changes. [8]

All the above-mentioned findings encouraged the use of medical grade calcium sulfate hemihydrate as a bone graft material for socket preservation. Calcium sulfate has a wide range of advantages over autografts, including higher biocompatibility, handling properties, porosity, different rates of dissolution, chemical and physical similarity to bone mineral, ability to induce the release of growth factors potentially limitless supply at a low cost, and inhibition of epithelial migration. Due to its different advantages and multifunctional attributes, it has been used for treatment of intra-bony defects showing commendable results. [17]

A case study of a 37-year-old man with an upper canine periodontal defect shed light on the handling characteristics and improvement in cost-effectiveness of the procedure, which was improved by the medical grade calcium sulfate demonstrating its supportive characteristics when mixed with other bone grafts. [18] The above-mentioned case report described the use of medical grade calcium sulfate without a barrier membrane. Calcium sulfate enhances soft tissue healing, and can serve as a barrier membrane. [19] The present results supported this statement since no barrier was used and good and satisfactory results were achieved.

A previous case report used a composite graft of MGCSH and MICBA for socket preservation and sinus augmentation and highlighted the optimal characteristics of the MGCSH such as improved handling properties, preventing the soft tissue in-growth and assisting bone regeneration. [20]This was well supported clinically in the present study.

Since there have been multiple reports on the fate of alveolar ridge after tooth extraction with no attempt for socket preservation, we did not use controls in the present study. [7, 21, 22]

Comparison of results obtained at 3 mm and 6 mm from the initial crest by using CBCT and acrylic stent in the present study with the findings of Toloue et al., 2012 [7], at 5 mm

apical to the gingival margin with the aid of a caliper and a stent, revealed horizontal ridge dimensional changes because it falls within that range. The change in horizontal dimension (loss) was 1.33 ± 1.22 mm in their study; this value was 1.49±0.18 mm at 3 mm and 1.56±0.32 mm at 6 mm in the present study. The vertical ridge dimensional change was 0.23 ±1.69 mm in their study. This value was 0.83 ±0.48 mm in the present study. Their results were in agreement with the present findings with respect to changes in both ridge width and height.

Kutkut et al., 2012[5] used MGCSH mixed with platelet-rich plasma (PRP) for socket preservation and measured the buccolingual width change to be -1.7 ± 0.6 mm; they showed quite similar result to our study when compared with changes at 3 mm and 6 mm in the present study. Slight differences in the results can be due to the effects of PRP.

Cheah et al., 2014 [3] in their study performed socket preservation using calcium sulfate and calcium sulfate-PRP for socket preservation. They assessed dimensional changes of the socket with the help of an acrylic stent and CBCT. The marking was different in their study as they placed 3 gutta-percha points on the buccal side and 1 on the lingual side at the mid-palatal or mid-lingual point. The baseline CBCT was taken after extraction while in our study it was taken before extraction. Their follow up period was 4 months, while it was 3 months in our study. Buccolingual width change was 1.69±0.76 mm in their study which was similar to the results obtained at 3 mm and 6 mm in the present study.

The mean width reduction in the present study showed better results when compared with the data of a previous systemic review by Van der weijen et al., 2009[23] who showed a mean width reduction of 3.87 mm which was quite high when compared with our study. However, the crestal height change in their study was 1.53 mm which was similar to the value obtained in the present study, showing that the MGCSH graft material is efficient in maintaining socket dimensions and proving its worth as a socket graft material.

In the current study, CBCT was performed before extraction and 3 months after socket preservation with MGCSH bone graft. CBCT was used for quantitative measurements in this study because it provides sub-millimeter precision for linear measurements and 3-dimensional and cross-sectional images without superimposition. [24, 25] Difficulties experienced during standardized evaluation of periapical films used in typical intraoral radiography

(i.e., positioning of patient and the density wedge rendering some films unreadable [26] and only obtaining mesial and distal dimensions by linear measurements [27]) were also prevented.

There was no control group in the present study. Current study is not trying to compare medical grade calcium sulfate hemihydrate with any other bone graft and only aimed to assess to what level it may maintain the height and width of the socket. That is the reason why pre and postoperative measurements were made on CBCT scans.

In the current study, we attempted to radiographically assess the efficacy of MGCSH after a 3-month follow-up.

In the present study, a minimal full-thickness flap was elevated prior to tooth extraction with no releasing incisions. However, even with such a flap, osteoclastic activity that mediates resorption of the superficial layer of the exposed alveolar bone might have occurred. [28]

MGCSH has been shown to be a useful and affordable grafting material. Due to the results and comparison with supporting studies, additional augmentation or surgical procedures will not be required and can be avoided simplifying the implant procedure planned for the future. The present study can be used as a template for future studies with a larger sample size, a control group, and selection of multi-rooted teeth, to verify its efficiency as a sole graft material for socket preservation.

Conclusion

The current study was the first to assess the change in socket dimensions following tooth

extraction and application of MGCSH to preserve the socket by using CBCT. The follow up period was 3 months. The results revealed a reduction in ridge width at the site of radiographic markers, after the follow up period. This clearly demonstrates the effectiveness of MGCSH bone graft and the importance of socket preservation procedure.

References

1. Tonetti MS, Jung RE, Avila-Ortiz G, Blanco J, Cosyn J, Fickl S, *et al*. Management of the extraction socket and timing of implant placement: Consensus report and clinical recommendations of group 3 of the XV European Workshop in Periodontology. Journal of clinical periodontology. 2019 Jun;46:183-94.
2. Beck TM, Mealey BL. Histologic analysis of healing after tooth extraction with ridge preservation using mineralized human bone allograft. Journal of periodontology. 2010 Dec; 81(12):1765-72.
3. Cheah CW, Vaithilingam RD, Siar CH, Swaminathan D, Hornbuckle GC. Histologic, histomorphometric, and cone-beam computerized tomography analyses of calcium sulfate and platelet-rich plasma in socket preservation: A pilot study. Implant dentistry. 2014 Oct 1;23(5):593-601.
4. Jung RE, Philipp A, Annen BM, Signorelli L, Thoma DS, Hämmerle CH, *et al*. Radiographic evaluation of different techniques for ridge preservation after tooth extraction: a randomized controlled clinical trial. Journal of clinical periodontology. 2013 Jan;40(1):90-8.
5. Kutkut A, Andreana S, Kim HL, Monaco Jr E. Extraction socket preservation graft before implant placement with calcium sulfate hemihydrate and platelet-rich plasma: A clinical and histomorphometric study in humans. Journal of periodontology. 2012 Apr;83(4):401-9.
6. Guarnieri R, Pecora G, Fini M, Giardino R, Orsini G, Piattelli A. Medical grade calcium sulfate hemihydrate in healing of human extraction sockets: clinical and histological observations at 3 months. Journal of periodontology. 2004 Jun;75(6):902-8.
7. Toloue SM, Chesnoiu-Matei I, Blanchard SB. A clinical and histomorphometric study of calcium sulfate compared with freeze-dried bone allograft for alveolar ridge preservation. Journal of periodontology. 2012 Jul;83(7):847-55.
8. Walsh WR, Morberg P, Yu Y, Yang JL, Haggard W, Sheath PC, *et al*. Response of a calcium sulfate bone graft substitute in a confined cancellous defect. Clinical Orthopaedics and Related Research. 2003 Jan 1;406(1):228-36.
9. Anson D. Calcium sulfate: a 4-year observation of its use as a resorbable barrier in guided tissue regeneration of periodontal defects. Compendium of Continuing Education in Dentistry. 1996 Sep 1;17(9):895-9.
10. Sottosanti J, Anson D. Using calcium sulfate as a graft enhancer and membrane barrier. Dental implantology update. 2003 Jan;14(1):1-8.
11. Vance GS, Greenwell H, Miller RL, Hill M, Johnston H, Scheetz JP. Comparison of an allograft in an experimental putty carrier and a bovine-derived xenograft used in ridge preservation: a clinical and histologic study in humans. International Journal of oral & maxillofacial Implants. 2004 Jul 1;19(4).
12. Rios HF, Borgnakke WS, Benavides E. The use of cone-beam computed tomography in management of patients requiring dental implants: An American Academy of Periodontology best evidence review. Journal of periodontology. 2017 Oct;88(10):946-59.
13. Temmerman A, Vandessel J, Castro A, Jacobs R, Teughels W, Pinto N, *et al*. The use of leucocyte and platelet-rich fibrin in socket management and ridge preservation: a split-mouth, randomized, controlled clinical trial. Journal of clinical periodontology. 2016 Nov;43(11):990-9.
14. Thakkar DJ, Deshpande NC, Dave DH, Narayankar SD. A comparative evaluation of extraction socket preservation with demineralized freeze-dried bone allograft alone and along with platelet-rich fibrin: A clinical and radiographic study. Contemporary clinical dentistry. 2016 Jul;7(3):371.
15. Kelly CM, Wilkins RM, Gitelis S, Hartjen C,

Watson JT, Kim PT. The use of a surgical grade calcium sulfate as a bone graft substitute: results of a multicenter trial. Clinical orthopaedics and related research. 2001 Jan 1; 382:42-50.
16. Strocchi R, Orsini G, Iezzi G, Scarano A, Rubini C, Pecora G, *et al*. Bone regeneration with calcium sulfate: evidence for increased angiogenesis in rabbits. Journal of oral implantology. 2002 Dec;28(6):273-8.
17. Pandit N, Sharma A, Jain A, Bali D, Malik R, Gugnani S. The use of nanocrystalline and two other forms of calcium sulfate in the treatment of infrabony defects: A clinical and radiographic study. Journal of indian society of periodontology. 2015 Sep;19(5):545.
18. Mazor Z, Mamidwar S, Ricci JL, Tovar NM. Bone repair in periodontal defect using a composite of allograft and calcium sulfate (DentoGen) and a calcium sulfate barrier. Journal of Oral Implantology. 2011 Apr; 37(2): 287-92.
19. Pecora G, Andreana S, Margarone III JE, Covani U, Sottosanti JS. Bone regeneration with a calcium sulfate barrier. Oral surgery, Oral medicine, Oral pathology, Oral radiology, and Endodontology. 1997 Oct 1;84(4):424-9.
20. Bagoff R, Mamidwar S, Chesnoiu-Matei I, Ricci JL, Alexander H, Tovar NM. Socket preservation and sinus augmentation using a medical grade calcium sulfate hemihydrate and mineralized irradiated cancellous bone allograft composite. Journal of Oral Implantology. 2013 Jun;39(3):363-71.
21. Iasella JM, Greenwell H, Miller RL, Hill M, Drisko C, Bohra AA, *et al*. Ridge preservation with freeze-dried bone allograft and a collagen membrane compared to extraction alone for implant site development: A clinical and histologic study in humans. Journal of periodontology. 2003 Jul;74(7):990-9.
22. Barone A, Aldini NN, Fini M, Giardino R, Calvo Guirado JL, Covani U. Xenograft versus extraction alone for ridge preservation after tooth removal: a clinical and histomorphometric study. Journal of periodontology. 2008 Aug; 79(8):1370-7.
23. Van der Weijden F, Dell'Acqua F, Slot DE. Alveolar bone dimensional changes of post-extraction sockets in humans: a systematic review. Journal of clinical periodontology. 2009 Dec;36(12):1048-58.
24. Ludlow JB. Regarding "Influence of CBCT exposure conditions on radiation dose". Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology and Endodontology. 2008; 5(106): 627-8.
25. Kerr EN, Mealey BL, Noujeim ME, Lasho DJ, Nummikoski PV, Mellonig JT. The effect of ultrasound on bone dimensional changes following extraction: a pilot study. Journal of periodontology. 2008 Feb;79(2):283-90.
26. Howell TH, Fiorellini J, Jones A, Alder M, Nummikoski P, Lazaro M, *et al*. A feasibility study evaluating rhBMP-2/absorbable collagen sponge device for local alveolar ridge preservation or augmentation. International journal of periodontics & restorative dentistry. 1997 Apr 1;17(2).
27. Schropp L, Wenzel A, Kostopoulos L, Karring T. Bone healing and soft tissue contour changes following single-tooth extraction: a clinical and radiographic 12-month prospective study. International Journal of Periodontics & Restorative Dentistry. 2003 Aug 1;23(4).
28. Lekovic V, Kenney EB, Weinlaender M, Han T, Klokkevold P, Nedic M, *et al*. A bone regenerative approach to alveolar ridge maintenance following tooth extraction. Report of 10 cases. Journal of periodontology. 1997 Jun; 68(6):563-70.