

# **Original Research Paper**

Surgery

# EVALUATING THE EFFICACY OF NANOCRYSTALLINE BETA-TRICALCIUM PHOSPHATE IN TYPE I COLLAGEN PLUG FOR PRESERVATION OF MANDIBULAR EXTRACTION SOCKETS- A PROSPECTIVE, CLINICAL AND RADIOGRAPHIC STUDY

Dr.Nisharudeen. K*	Director, Deen Dentofacial clinics, Madurai. *Corresponding Author
Dr.Mohanavalli. S	Professor & Head, ESI Medical College, Chennai.
Dr. Krishnakumar Raja.V.B	Professor & Head, Department of Oral and Maxillofacial Surgery, SRM Dental College, Chennai.

# ABSTRACT

**Context:** Healing process after tooth extraction never results in complete restitution of the original alveolar bone volume due to physiologic resorption. Various methods have been tried in literature for preservation of the trade and the law of the second sec

extraction socket. This study evaluates the efficacy of Beta-Tricalcium phosphate in type I collagen plug for preservation of mandibular extraction sockets.

Aims and objectives: Aim of this study is to evaluate the healing of extraction sockets preserved with Beta-Tricalcium phosphate in type I collagen plug clinically and radiographically and to compare them with normal healing sockets.

Settings and Design: Prospective, randomised controlled clinical trial with split mouth design was selected to avoid individual variations in the healing process.

**Methods and Material:** 10 systemically healthy adult patients, 22-32 years of age (mean age: 26.6 years), who underwent surgical removal of bilateral impacted third molars in the mandible was selected for the study. One side was grafted with test material and other was left to heal spontaneously as control side. Healing was evaluated clinically and radiographically using CBCT greyscale values.

Statistical analysis used: Independent samples t-test was used to compare the mean differences in socket dimensions and mean CBCT grey scale values. Non-parametric Mann-Whitney test is used to compare the clinical attachment levels

**Results:** Sites grafted with the study material when compared to control side showed

1. Better clinical attachment levels

2. Significant reduction in alveolar crestal bone loss and

3. Better bone quality

**Conclusions:** Results obtained showed that there is a significant improvement in quantity and quality of alveolar bone if preserved with Beta-Tricalcium phosphate in type I collagen plug, which is more suitable for future dental implant placement.

KEYWORDS : Socket preservation, Beta-Tricalcium phosphate, Alveolar bone grafting.

# Introduction:

Bone defects are unavoidable in oral and maxillofacial surgical practice from simple extraction sockets to complex jaw resections, which results in both functional and aesthetic compromise. Bone grafting is done to address this problem and to restore the form and function.

Healing process after tooth extraction never results in complete restitution of the original alveolar bone volume due to physiologic resorption. Adequate volumes of alveolar bone which are close to the original dimensions of the alveolar process are necessary to provide favourable aesthetics and successful long-term outcomes for dental implants. Therefore, preservation of extraction socket dimensions has been attempted by many investigators immediately following tooth extraction. Preservation of human extraction socket by placement of a cone of beta-tricalcium phosphate (B-TCP) combined with type I collagen without the use of barrier membranes or flap surgery was tried in 2008<sup>1</sup> and resulted in formation of new bone of acceptable quality and quantity which permitted the placement of an osseointegrated dental implant later<sup>1</sup>. Studies also suggest that there is no considerable difference in healing between the beta-tricalcium phosphate (B-TCP) placed with or without barrier membrane or flap advancement<sup>2</sup>.

Only long term (9 months) studies on alveolar ridge preservation with Beta tricalcium phosphate<sup>2</sup> are available till date. Also, Nanocrystalline beta tricalcium phosphate in type I collagen plugs were recently introduced. Hence, a short term (4 months) study with the new material was done to evaluate the efficacy of the new material.

### 1. Investigate the healing of human extraction sockets filled with Nanocrystalline beta tricalcium phosphate/type I collagen plugs and to compare them with normally healing sockets clinically and radiographically with four months follow up.

- 2. To compare difference in the alveolar bone resorption rates of grafted and non grafted sockets after 4 months.
- To compare the quality of bone in the grafted and non grafted side at the end of four months by cone beam CT grey scale values.
- To compare the difference in healing of distal periodontal tissues in between the grafted and non grafted sides at various time intervals.

# Materials and Methods:

A prospective study was conducted consisting of 10 patients, 22-32 years of age (mean age: 26.6 years), who underwent surgical removal of impacted mandibular third molars in the department of Oral & maxillofacial surgery, SRM Dental College, Ramapuram, Chennai. All patients were healthy adults with ASA status I having bilateral impacted third molars indicated for extraction. Written consent was obtained from all the patients.

Patients with any systemic or metabolic diseases, Cardiac disorders, drug allergies, poor periodontal status, Pregnant or nursing mothers, smokers and patients unable to comply with study protocol were excluded from the study.

# Surgical technique:

Preoperatively patient prepared with 5% povidone iodine painting, 0.2 chlorhexidine mouthwash and draping done. Local anesthesia (2% lignocaine with 1:80000 adrenaline) given by inferior alveolar nerve block technique. Ward's incision was placed, mucoperiosteal flap elevation done, lingual nerve protected, buccal and distal bone

Aims and objectives: The aim of this study is to

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guttered around the impacted teeth. Tooth split was done if needed. Impacted tooth was elevated. Distal curettage was done on both sides to remove the granulation tissue. Then the control site was sutured with 3-0 silk suture as a routine procedure. The Nanocrystalline beta-tricalcalcium phosphate in type I collagen plug was placed in the experimental side socket and flap closed with 3-0 silk sutures.

Antibiotics were prescribed for all cases preoperatively one day prior to the surgery and postoperatively antibiotics and analgesics were continued for five days. Immediate postoperative OPG and mandibular CBCT were made to elicit the dimensions of socket.

Post-operative follow up was done on third day, seventh day, first month, second month, third month and fourth month and clinical attachment level was measured distal to mandibular third molar in distobuccal, distal and distolingual to second molar with William's periodontal probe and deepest observation was recorded. OPG was taken in all follow up appointments and Mandibular CBCT was taken in fourth month. Preoperative and postoperative socket dimensions and postoperative greyscale units with their range and median values were obtained and tabulated.

Statistical analysis of the parameters obtained was conducted by SPSS for Windows, Version 15 (SPSS Inc., Chicago, IL). The Kolmogorov-Smirnov and Shapiro-Wilk test results showed that the variables CBCT Grey scale and Socket dimensions followed Normal distribution. Therefore to analyze these variables Parametric Samples t-test is used. Clinical attachment levels did not follow Normal distribution therefore Non-parametric Mann-Whitney test was used to compare between sides. Any p value less than 0.05 was considered significant.

#### **Results:**

Clinically, healing was uneventful. By the seventh day, the socket was completely covered with mucosa. During the 4 months of observation, no loss of material, no signs of infection, exudation or sinus formation at the area of the extraction and ridge preservation wound were noted. There are no significant differences in postoperative pain and swelling observed.

The difference between the preoperative and postoperative alveolar bone dimensions is found in all the three aspects and their mean values were calculated for both the grafted and control sides individually and the statistical significance was tested. The Kolmogorov-Smirnov and Shapiro-Wilk test results showed that the variables alveolar bone dimensions followed Normal distribution. Therefore to analyse these variables Parametric test is applied. To compare the mean values between sides independent samples ttest is used.

Results showed that the difference in the reduction in alveolar bone height and mid-level width of the grafted and non grafted sides are not statistically significant but the resorption of the alveolar crestal bone width is statistically significant (tables 2 & 3).

The Kolmogorov-Smirnov and Shapiro-Wilk test results showed that clinical attachment level values does not follow Normal distribution therefore Non-parametric Mann-Whitney test is used to compare between sides. Results of the analysis shows that there is statistically significant difference in clinical attachment levels of grafted and control sides in all four months. Thus the periodontal attachment loss is lesser in grafted side than the control side at all time intervals (tables 4, 5 & 6).

The Kolmogorov-Smirnov and Shapiro-Wilk test results showed that the CBCT Grey scale values followed Normal distribution. Therefore to analyze these variables, Parametric test is applied. To compare the mean values between sides independent samples t-test is used. The results shows that the difference in median, minimum, maximum CBCT grey values is statistically significant in between grafted and control sides. Hence the quality of bone in the grafted side is better than the control side (tables 7 & 8).

#### **Discussion:**

Beta-tricalcium phosphate is known to be osteoconductive, has been shown to be resorbable and simultaneously capable of supporting new bone formation both in animal models<sup>36</sup> and in human trials<sup>7</sup> but lacks growth factors and cellular components and therefore has no osseoinductive properties.

Some of the remarkable properties of beta tricalcium phosphate are that they do not alter human plasma calcium and phosphate levels<sup>8</sup>, tissue compatibility is superior to other synthetic materials, do not induce foreign body reaction<sup>9</sup>, resist fibroblastic in growth into the graft<sup>10</sup> (i.e., there is no intervening layer between the graft and native bone<sup>11</sup>), no systemic or local toxicity and do not result in hemolysis or mutation<sup>12</sup>.

The advantages of using nanoparticles have been studied earlier and they have found that they have faster resorption rate, better tissue compatibility and less inflammatory response<sup>13,14</sup> when compared to microparticles of the same graft. Adding type I collagen to the beta-tricalcium phosphate particulate grafts increases the osteocoductivity<sup>15</sup>, results in rapid regeneration <sup>16</sup>, prevents epithelial ingrowth and its spongeous form can be easily handled and provide a better intraoral manipulation<sup>17</sup>.

Beta-tricalcium phosphate + type I collagen had been used for alveolar bone preservation in maxilla<sup>1,2</sup>, maxillary sinus floor elevation and mandibular cyst removal<sup>20,21</sup> and is found to be successful in all these applications. There is no significant advantage observed with the placing of barrier membrane or flap advancement over the graft<sup>20</sup>.

Only long term (9 months) studies with Beta tricalcium phosphate<sup>2</sup> are available till date and moreover Nanocrystalline beta tricalcium phosphate in type I collagen plugs are recently introduced. Hence a short term (4 months) study with the new material was done.

We selected split mouth design for our study because we can study the nature of bone formation with and without the graft in the same individual under the influence of same external and internal environments hence reducing the inter individual variations. The graft's ability to resist alveolar bone resorption, induce new bone formation and the quality of bone formed can be compared with the natural healing process in the same individual.

To study the characteristics of the graft various models can be used, we selected third molar extraction sockets because of easy bilateral availability, availability in young individuals free from any systemic condition and with good periodontal status. Patient is also benefitted by reduction in distal periodontal pocket<sup>22</sup> which is a common complication after surgical removal of mandibular third molar. Moreover the results obtained can be applied to other extraction sockets because it has been proved that there is no significant change in the quality and quantity of the bone formed irrespective of whether the socket is closed with flap advancement or left to heal spontaneously with the graft exposed to other scenarios requiring grafting in the mandible.

The buccal bone plate, comprised almost entirely of bundle bone, demonstrates marked osteoclastic resorption in the coronal region of the socket<sup>20</sup>. The early resorption of buccal bundle bone, which takes place during the first 8 weeks following extraction, proceeds with a marked reduction predominantly in the horizontal dimension<sup>21</sup>. A reduction in vertical ridge height of 0.8 mm over a 3 month period also predominates on the buccal aspect<sup>21</sup>. The main aim of alveolar bone preservation is to reduce the osteoclastic resorption of buccal bone in coronal aspect so that sufficient bone is available for the placement of dental implant in the future.

Cone beam computed tomography is used in our study to analyse the bone quality and quantity, since it's a non-invasive procedure. The radiation exposure is very minimal and higher level of detail obtained when compared to the conventional computed tomography which was used in the previous studies. We used Cone beam computed tomography for evaluating the bone quality by using grey scale units instead of biopsy because of ethical reasons and it has been proved that Grey scale units are reliable in predicting the quality of bone<sup>23</sup>. It is possible to predict initial implant stability and possibility of immediate or early loading using CBCT scans prior to implant placement<sup>24</sup>.

The results of our study shows that there is significantly increased alveolar ridge resorption in crestal region of alveolar bone in the control site, with a mean difference of 0.438 mm more bone in the grafted side. There is no statistically significant reduction in resorption of the height and midlevel width of the alveolar bone in between the grafted and control side. Thus it's proved that beta-tricalcium phosphate+type I collagen plug can reduce effectively the initial alveolar crestal bone in the buccal aspectthus providing a wider surface for the future implant placement. The results coincide with the previous studies<sup>12</sup>.

Clinical attachment levels showed that there is significantly less periodontal attachment loss distal to mandibular second molar in the grafted site in all the time intervals observed in our study. Hassan KS et al, in 2012<sup>22</sup> used xenograft plus a membrane as grafting material and compared it with normal healing sockets in a similar study design and published similar results that grafting reduces future periodontal disease with increased bone fill. Xenograft a has risk of inducing immune response in humans, hence its always safe to use alloplasts like Beta –tricalcium phosphate + Type I collagen for the purpose which does not have any adverse effects. Thereby patients with periodontal defect distal to mandibular second molar can be grafted immediately after the surgical removal of mandibular third molar to gain the bone and clinical attachment level.

The bone quality on grafted and control sites are compared by cone beam computed tomography grey scale values. The median, lowest limit and highest limit are obtained and compared. Results showed that statistically significant difference exists in all the three values between the two sites.

Another important finding is that the mean of the lowest values observed in control site is 117.9 corresponds to type 3 bone<sup>23</sup>. While the mean of the lowest values in grafted side is 213.7 corresponds to type 4 bone<sup>23</sup> which is best suited for implant placement and this quality of bone has highest initial and long term implant stability<sup>25</sup>.

The mean of the median values of grafted and control sides are 316.5 and 258.4 respectively both are type 2 quality values and both are suitable for implant placement<sup>25</sup> but the quality of the bone is better in the grafted side. Older studies using Hounsfield units derived from computed tomography also showed similar results<sup>2</sup>, hence dental implants can be placed successfully in mandible four months after extraction and alveolar bone preservation with Nano crystalline beta-tricalcium phosphate + type I collagen plug.

# Conclusion:

These findings suggests that Nano crystalline beta-tricalcium phosphate + type I collagen plug can be used routinely for alveolar ridge preservation and in augmentation of other iatrogenic or pathologic defects. This composite graft can also be used for grafting the socket after surgical removal of mandibular third molars to prevent the future distal periodontal tissue loss. Future studies should be directed towards assessing the volume of graft needed according to the size of the defect should to standardize the grafting procedure. Figure 1: Materials and methods



### Table 1: Demographic data.

S.No.	Age/sex
1	24/M
2	23/F
3	29/F
4	32/F
5	25/F
6	29/M
7	25/F
8	27/M
9	30/F
10	22/M

Mean age -26.6 Number of male patients -4 Number of female patients -5

 Table 2: Immediate postoperative and fourth month alveolar

 bone dimensions obtained from CBCT.

Ccas	Alveolar bone dimensions in mm											
e No.		G	irafte	ed sic	le		Control side					
	Pre	opera	ative	Post	oper	ative	Pre operative			Post operative		
	Α	В	С	Α	В	С	Α	В	С	Α	В	С
1	11.9	13.9	15.6	10.8	13.0	15.5	13.5	11.1	15.7	12.9	5.8	15.5
2	12.5	13.2	14.8	11.7	12.6	14.7	11.4	12.1	13.1	10.3	7.7	12.9
3	10.7	12.6	13.9	9.9	12.1	13.7	12.4	13.1	14.9	11.1	8.2	14.9
4	14.1	13.7	14.3	13.6	12.4	13.9	14.3	14.0	14.6	13.5	9.1	14.0
5	11.7	13.7	14.4	10.6	12.8	14.5	13.3	12.4	14.5	12.7	5.6	14.3
6	13.4	14.3	14.9	12.4	13.5	14.3	12.9	13.4	14.2	11.8	8.6	13.1
7	16.1	14.3	15.1	15.6	13.6	14.7	16.3	14.1	15.9	14.2	9.9	14.1
8	10.6	12.7	13.8	9.5	11.9	13.1	12.1	13.6	14.1	10.5	8.3	13.4
9	12.4	13.1	14.7	11.6	12.5	14.5	11.3	12.1	12.9	10.1	7.1	11.7
10	13.8	13.3	13.9	12.4	11.9	13.6	13.3	13.1	13.6	12.6	8.7	12.9

#### Legends:

- A- Height of alveolar bone above inferior alveolar nerve canal in mm
- B- Alveolar Crestal width in mm
- C- Alveolar Midlevel width in mm

**Table 3:** Independent samples t-test to compare the mean differences in socket dimensions of pre and post treatment values between Grafted and control sides.

Variables	Side	Ν	Mean	Std.	P-Value
				deviation	
Difference of	Grafted	10	0.910	0.285	0.270
Socket dimensions in A	Control	10	1.110	0.477	
Difference of	Grafted	10	0.850	0.295	< 0.001
Socket dimensions in B	Control	10	5.000	0.733	1
Difference of	Grafted	10	0.290	0.242	0.073
Socket dimensions in C	Control	10	0.670	0.564	

Statistically significant if P < 0.05.

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# Table 4: Clinical attachment levels in various time periods measured in mm.

Case	Clinical attachment level (in mm)								
no		Grafte	d side			Contro	ol side		
	1 <sup>st</sup>	2 <sup>nd</sup>	3 <sup>rd</sup>	4 <sup>th</sup>	1 <sup>st</sup>	2 <sup>nd</sup>	3 <sup>rd</sup>	4 <sup>th</sup>	
	month	month	month	month	month	month	month	month	
1	4	3	2	2	4	3	3	3	
2	3	2	2	2	3	3	2	2	
3	3	3	2	2	4	4	3	3	
4	3	3	2	2	4	4	3	3	
5	2	2	1	1	3	2	2	3	
6	4	3	3	2	5	3	3	2	
7	3	2	2	1	4	3	3	2	
8	4	3	2	2	6	4	4	3	
9	2	2	1	1	4	3	2	2	
10	3	2	2	2	5	4	3	3	
Mean	3.1	2.5	1.9	1.7	4.2	3.3	2.8	2.6	

#### Table 5: Descriptive Statistics of clinical attachment levels (CAL)

Side	Statistics	CAL at	CAL at	CAL at	CAL at
		1 month	2 month	3 month	4 month
Grafted	N	10	10	10	10
	Mean	3.10	2.50	1.90	1.70
	Std. Dev	0.74	0.53	0.57	0.48
	Minimum	2.00	2.00	1.00	1.00
	Maximum	4.00	3.00	3.00	2.00
	1 <sup>st</sup> quartile	2.75	2.00	1.75	1.00
	Median	3.00	2.50	2.00	2.00
	3 <sup>rd</sup> quartile	4.00	3.00	2.00	2.00
Control	N	10	10	10	10
	Mean	4.20	3.30	2.80	2.60
	Std. Dev	0.92	0.68	0.63	0.52
	Minimum	3.00	2.00	2.00	2.00
	Maximum	6.00	4.00	4.00	3.00
	1 <sup>st</sup> quartile	3.75	3.00	2.00	2.00
	Median	4.00	3.00	3.00	3.00
	3 <sup>rd</sup> quartile	5.00	4.00	3.00	3.00

# Table 6: Mann-Whitney U Test to compare between sides at each time point.

Time points	Side	N	Mean Rank	P-Value
CAL at 1 month	Grafted	10	7.35	0.012
	Control	10	13.65	
CAL at 2 month	Grafted	10	7.50	0.013
	Control	10	13.50	
CAL at 3 month	Grafted	10	7.15	0.006
	Control	10	13.85	
CAL at 4 month	Grafted	10	6.90	0.002
	Control	10	14.10	

Statistically significant if P < 0.05.

### Table 7: Median CBCT Grayscale values in subcrestal bone centered buccolingually.

Case no.	Median post operative greyscale units with their range.						
	Grafted side	Control side					
1	296.4(197-543)	239.8(115-438)					
2	314.7(213-584)	245.6(107-384)					
3	289.5(221-497)	257.6(94-371)					
4	359.7(276-594)	315.8(163-468)					
5	319.2(204-514)	254.1(103-394)					
6	328.3(217-531)	246.1(111-402)					
7	305.4(179-462)	268.1(135-399)					
8	284.9(126-401)	224.1(86-357)					
9	342.7(281-586)	271.8(146-482)					
10	324.6(223-594)	261.3(119-379)					

# Table 8: Independent samples t-test to compare the mean CBCT grey scale values between crafted and control sides.

Variables	Side	Ν	Mean	Std. Dev	P-Value
CBCT Grey scale	Grafted	10	316.5	23.6	<0.001
(Median)	Control	10	258.4	24.6	
CBCT Grey scale	Grafted	10	213.7	44.5	<0.001
(Minimum)	Control	10	117.9	23.8	
CBCT Grey scale	Grafted	10	530.6	64.1	<0.001
(Maximum)	Control	10	407.4	41.7	

Statistically significant if P < 0.05.

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