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Comparison of Bone grafts for Alveolar ridge dimensional preservation

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Abstract:

Introduction: Alveolar bone remodeling after tooth extraction has been long considered unavoidable. Ridge resorption is greatest within 6 months. Bone dimensional changes complicate tooth replacement therapy. Recently, the use of biomaterials for ridge preservation has been researched thoroughly. The main question is whether there are any benefits of bone grafting to the extraction socket. **Objectives:** The aim of the study was to determine the effect that socket filling with a bone graft has on alveolar ridge volume loss as compared with tooth extraction alone. **Materials and methods:** A database search was conducted according to the PRISMA guidelines. We searched for studies published between 01.10.2012 and 01.10.2017. **Results:** Five studies investigated alveolar ridge bucco-oral dimension preservation using xenograft. Overall, the interventions with this graft were more beneficial in terms of width maintenance than tooth extraction alone. Four articles analyzed socket bucco-oral dimension maintenance using synthetic alloplast. The results were inconclusive, as 3 studies reported greater width and one article described a greater bone width in the control group. Four studies investigated the preservation of alveolar bone height after socket preservation. In the bovine derived xenograft subgroup, the effect of ridge height was greater than extraction alone. Two studies researched ridge height preservation after extraction using synthetic alloplast. The results were in favor of the test group, but were statistically insignificant. **Conclusions:** Alveolar ridge preservation using xenograft shows greater dimensional preservation than no graft. The results for the alloplast group were inconclusive. More and less heterogeneous studies are needed to compare these materials.

Key words: Alveolar ridge preservation, alloplast, xenograft, tooth extraction

Introduction:

Periodontal disease, periapical pathology and mechanical trauma often result in bone loss prior to tooth removal[1]. Alveolar bone remodeling after tooth extraction has been long considered as an unavoidable consequence of this procedure.[2,3,4] This phenomenon seems to be progressive and irreversible. The amount of the horizontal bone loss is usually the greatest and mostly occurs on the buccal plate. The resorption of vertical bone height is slighter and more pronounced on the facial side as well.[5,6,7] The rate of ridge resorption is greatest in the first year, especially within the first 6 months[8,9,10,11] These alveolar bone dimensional changes may complicate prosthodontic, particularly when implant-supported restorations are planned. Considerable tissue loss leads to increased difficulty in placing the dental implant in a prosthodontically suitable position. To facilitate such placement, guided bone regeneration (GBR) procedures (either simultaneous at implant placement or staged as a separate surgical procedure) are often necessary. To overcome this problem, the use of biomaterials for alveolar ridge preservation has been researched thoroughly. Over the past years, growing interest has emerged regarding a notion called “alveolar ridge preservation”, which was defined as “any procedure undertaken at the time of or following an extraction that is designed to minimize external resorption of the ridge and maximize bone formation within the socket”.[12] The ultimate goal of the bone graft material is to provide a scaffold to conduct the formation of blood vessels, improve the quality and quantity of the new formed bone, protect blood clots, and support the

soft tissue flap. The main question is whether there is any benefit of grafting or guided bone regeneration efforts to manage the extraction socket. Moreover, does placing a graft after the extraction improve the site dimensionally? Autogenous bone is considered the gold standard of bone substitute materials due to its osteo-inductive effect. On the other hand, acquiring this type of graft can cause more harm than good.[13] Also autogenous bone has a tendency to resorb rapidly thus diminishing the ever important osteo-inductive effect.[14,15] A number of xenogenic and synthetic substitutes are being used instead. Xenogenic bone offers osteo-inductive and osteo-conductive properties, yet there is a risk of transmitting zootopic infection and is expensive. [16] Osteo-conductive materials may stimulate the recruitment and migration of potentially osteogenic cells to the site of matrix formation. [17] The term osteoinduction refers to the property of the material to induce differentiation of undifferentiated cells toward an osteoblastic phenotype.[18] On the other hand, alloplastic bone substitutes have only osteoconductive features.[19,20,21] In this study, we have attempted to answer which type of graft was the most suitable for maintaining the dimensions of the alveolar bone after extraction of incisor, canine and premolar teeth. The aim of study was to determine the effect that socket filling with a bone grafting material has on the prevention of post-extraction alveolar ridge volume loss as compared with tooth extraction alone in anterior and premolar teeth.

Materials and Methods:

Study selection

A comprehensive PubMed (Medline) database search was conducted according to the PRISMA guidelines for systematic reviews.[5] We used following keywords: (("bone graft") or (“alloplastic”) or (“xenograft”)) or (“alveolar ridge preservation”) or ("socket preservation"). We searched for clinical studies published between 01.10.2012 and 01.10.2017 in English language. Manual searches of reference lists from selected full articles complemented the electronic search.

Protocol

This systematic review was based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement for systematic reviews.[22]

Focus question

The aim of this systematic review and meta-analysis was based on following focus questions:

- Does alveolar ridge preservation therapy make a statistically significant improvement to the volume change of alveolar bone after tooth extraction?
- Which type of bone graft has the biggest influence to alveolar ridge preservation?

Information sources

Systematic article search was performed in MEDLINE (PubMed) online library.

Search

Online search strategy was: [("bone graft") or (“alloplastic”) or (“xenograft”)] or (“alveolar ridge preservation”) or ("socket preservation"). Following filters were incorporated into systematic search-

- studies published between 01.10.2012 and 01.10.2017
- Studies published in English language.

Flow diagram of search results according to PRISMA guidelines is presented in **Figure I**.

Study selection

Primary literature search was performed by screening article titles. Abstracts were read when relevant titles were found. Full texts were screened when abstracts were relevant or unavailable. Full texts fitting our inclusion criteria were included into meta-analysis.

Inclusion criteria:

1. Randomized controlled clinical trials
2. Studies on humans in which only healthy individuals participated
3. Studies reporting on the preservation of width or height, 6 months after alveolar ridge maintenance procedure
4. Studies performing one of the following measurement methods: clinical measurement or three-dimensional radiographic evaluation.
5. Extraction of incisors, canines and premolars
6. Studies that used bovine derived xenograft and synthetic alloplast for socket grafting

Exclusion criteria:

1. Case reports, case series
2. Studies on patients with systemic disease (diabetes, chemotherapy, immunosupressive disease)
3. Articles that included patients smoking more than 10 cigarettes a day
4. Studies reporting on sinus lift, lateral and horizontal alveolar bone augmentation
5. Articles that presented data converted to percentages.

Data collection process

The data were independently extracted from studies in the form of variables, according to the aims and themes of the present review. Data collection form was employed to ensure systematic recording of data. Other relevant study data was also recorded.

Data items

Following data items were recorded from each included study:

- Author, year and name of study
- Type of bone grafts
- Intervention and control groups
- Extracted tooth
- Treatment duration
- Quantitative data on alveolar bone volume change

Statistical analysis

Statistical analysis was performed using MedCalc Version 18.2.1 (computer program). Separate meta-analyses were performed on periodontal ligament, alveolar bone and cementum regeneration measures by using Z test with random effects weighted inverse variance method. Standardized mean difference meta-analysis was chosen. Study heterogeneity was assessed using I^2 test.

Results:

Database search provided 1689 results. After title screening, 210 abstracts matched our review theme. Sixty five abstracts mentioned alveolar ridge preservation, seven studies fitted our inclusion criteria. Six of the selected studies reported on the preservation of alveolar bone width. The articles researching the preservation of socket width were divided into subgroups according to graft source and measurement of alveolar bone height and width.

Risk of bias in individual studies

Studies were categorized according to the Cochrane's risk of bias tool.[23] Risk of bias in individual studies is presented in **Figure II**. In general, none of the given sources were of low risk of bias and only Kotsakis et al and Sbordone et al [24, 25] conducted studies of medium risk of bias. **Figure II** presents the risk of bias across all studies. Most of the studies conducted randomization of test and control groups. None of the reviewed articles submitted selective reporting. All of the included studies presented other forms of bias, such as not calculating sample size.

Description of included studies

Six articles were included in meta-analysis with a total of 196 grafted sockets (**Table I**). All of the included studies researched ridge preservation using bovine derived xenograft and 4 of them using synthetic alloplast (including hydroxyapatite and calcium sulfate). Width change was

reported in 5 articles and height change was reported in four studies.

Figure I: PRISMA flow diagram demonstrating the results of systematic literature search

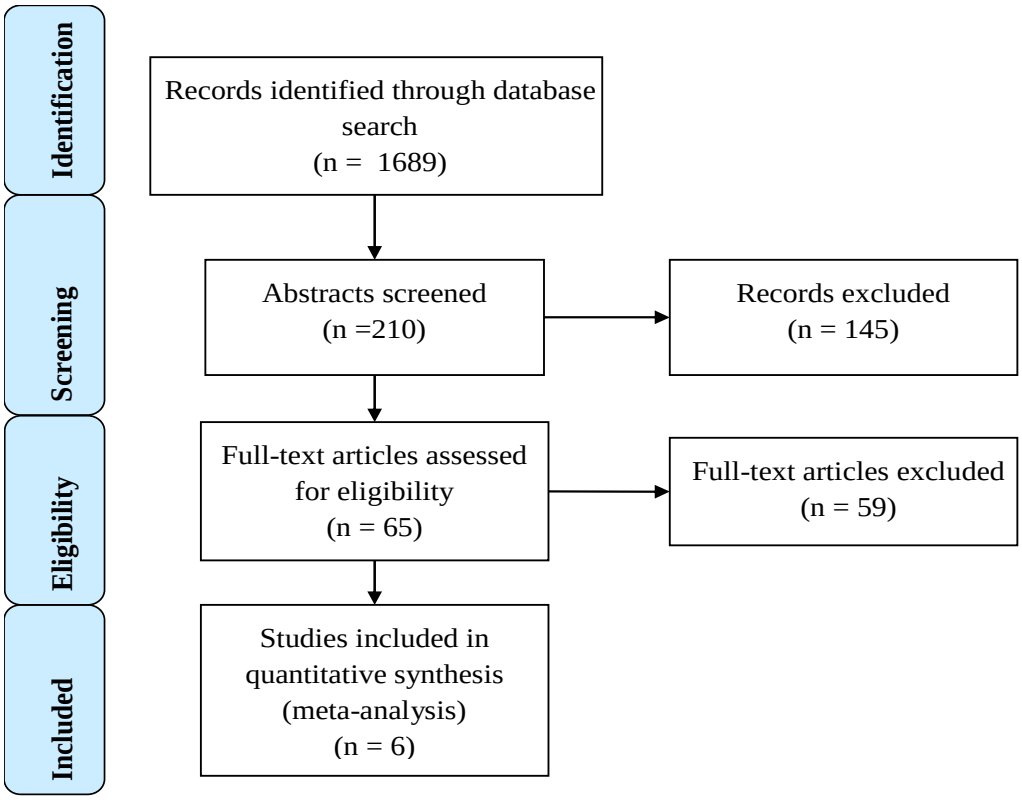


Figure II: Risk of bias in included studies

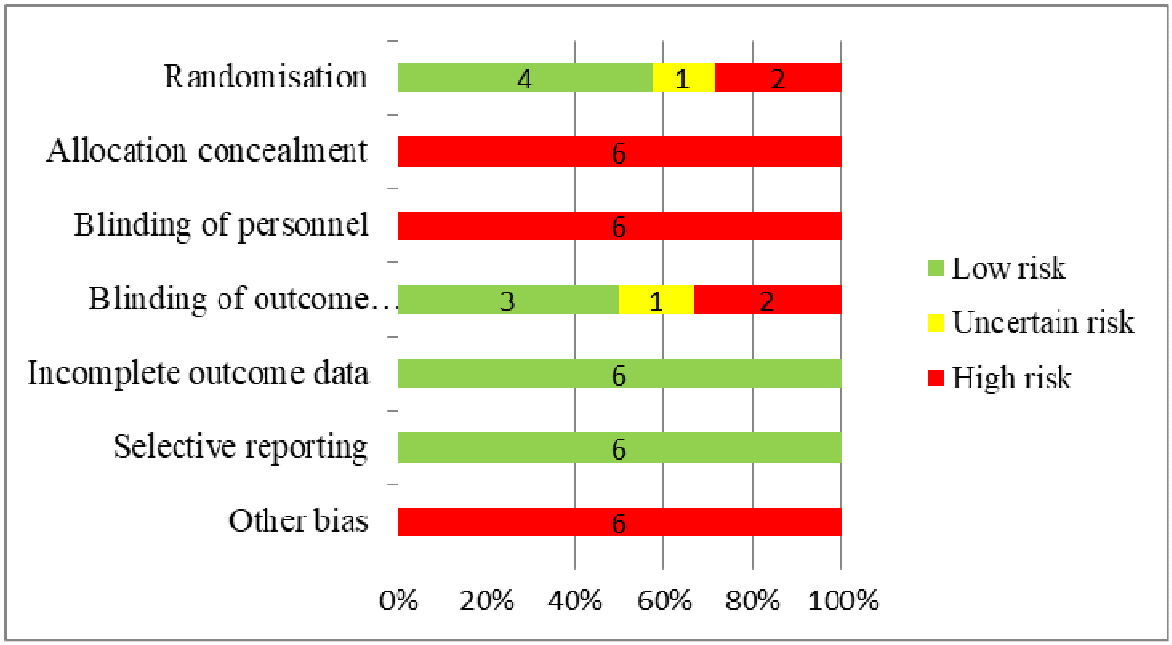


Table I: Studies included in the meta-analysis

Author	Year	Graft type	Healing time	Number	Gruops	Width change, mm (SD)	Height change, mm (SD)	Extracted teeth
Festa *et al.* [27]	2013	Xenograft	6 months	30				Premolar
				15	DBBM	-1.8 (1.3)	-2.4 (1.6)	
				15	Control	-3.7 (1.2)	-3.1 (1.3)	
Jung *et al.* [28]	2013	Xenograft, alloplast	6 months	40				Anterior or premolar
				10	CS	-6.1 (2.5)	-0.9 (2.0)	
				20	DBBM	-1.2 (0.8)	-1.8 (2.1)	
				10	Control	-3.3 (2.0)	-2.0 (1.9)	
Shakibaie *et al.* [29]	2013	Xenograft, alloplast	10 weeks	32				Premolar or anterior
				11	DBBM	-0.5 (0.86)	-1.0 (0.87)	
				11	HA	-1.5 (0.85)	-1.5 (0.90)	
				10	Control	-2.0 (0.72)	-2.0 (0.87)	
Kotsakis *et al.* [25]	2014	Xenograft, alloplast	5 months	30				Premolar
				12	DBBM	-1.36 (0.57)	No data	
				12	CS	-1.26 (0.41)		
				6	Control	-2.53 (0.59)		
Schneider *et al.* [30]	2014	Xenograft, alloplast	6 months	40				Anterior or premolar
				10	CS	-1.7 (0.7)	No data	
				20	DBBM	-1.2 (0.5)		
				10	Control	-1.8 (0.8)		
Sbordone *et al.* [26]	2016	Xenograft	6 months	24				Anterior
				9	Control	No data	-1.7 (1.3)	
				15	DBBM		-0.5 (1.2)	

SD- standart deviation; DBBM- deproteinized bovine bone mineral; CS- calcium sulphate; HA- hydroxyapatite

Figure III: Forest plot showing weighted mean average for alveolar width preservation using bovine derived xenograft

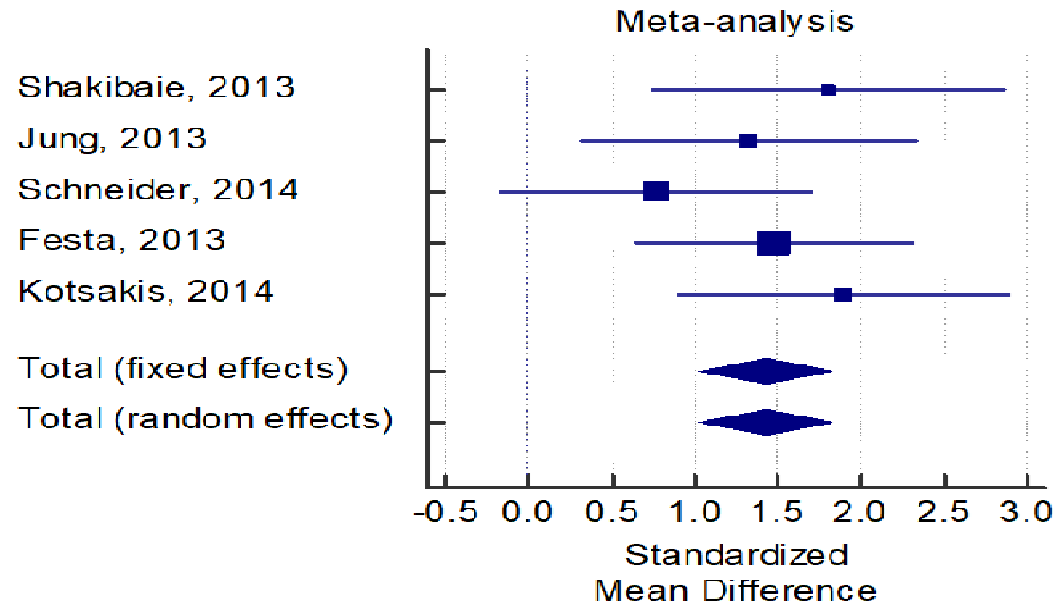


Figure IV: Forest plot showing weighted mean average for alveolar ridge width preservation using alloplastic bone graft

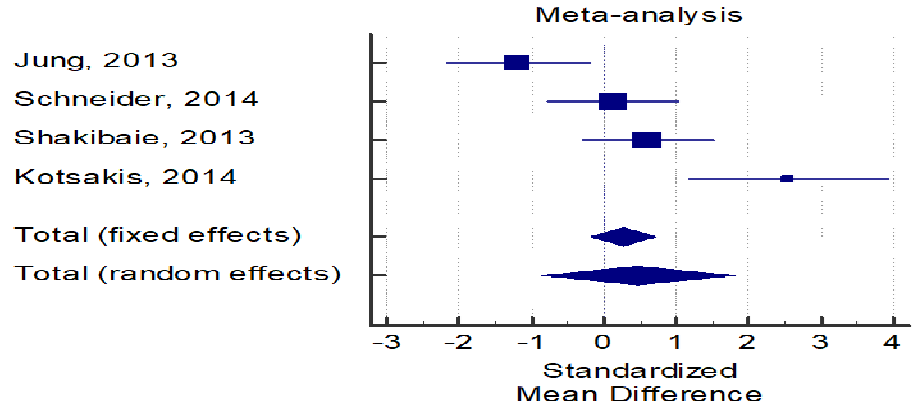


Figure V: Forest plot showing weighted mean average for alveolar ridge height preservation using bovine derived xenograft

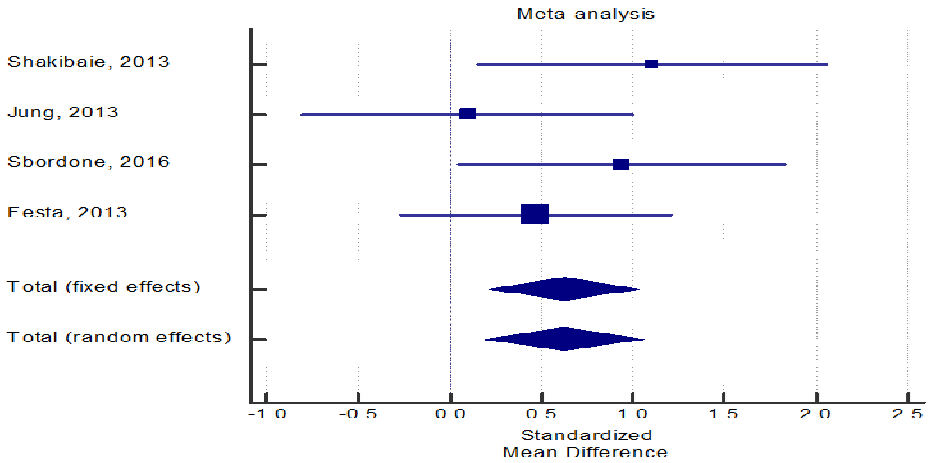
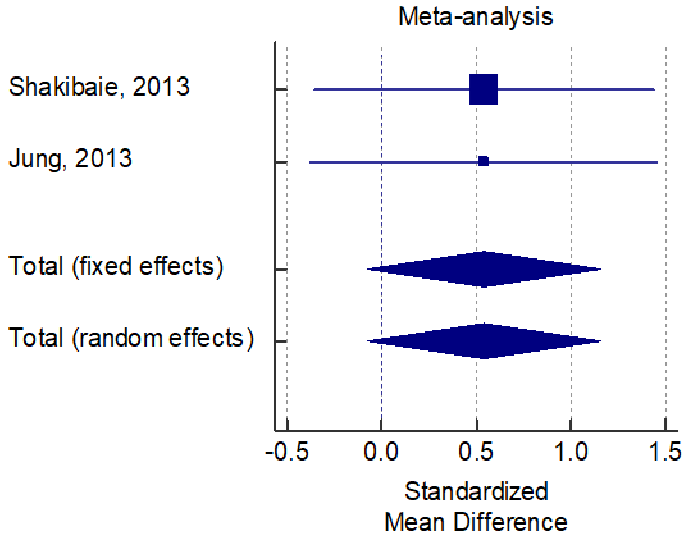


Figure VI: Forest plot showing weighted mean average for alveolar ridge height preservation using synthetic alloplast



The most frequently adopted treatment duration was 6 months. The majority of studies (4 out of 6) measured socket dimensions radiographically. Two articles calculated ridge dimensions by means of individual templates.

Alveolar ridge width preservation using xenograft

Five studies investigated alveolar ridge bucco-oral dimension preservation using bovine derived xenograft.[24,25,26,27,28,29] Overall, all studies concluded that socket grafting with xenograft were more beneficial in terms of alveolar bone width maintenance than tooth extraction alone (weighted mean average of -1.31 mm versus -2.78mm, P <0,0001). Study results were homogeneous (I^2 = 0%, P = 0.4319). The standardized mean difference in width preservation was 1.429 (95% confidence interval: 1.023 to 1.834, P<0.001) (**Figure III**).

Alveolar ridge width preservation using alloplast

Four articles analyzed socket bucco-oral dimension maintenance using synthetic alloplastic graft.[24,27,28,29] The results were inconclusive, as 3 out of 4 studies reported greater socket width after alveolar ridge preservation procedure. Jung et al described a greater bone width in the control group after 6 months.[27] The weighted mean average for the alloplast subgroup was 2.7 mm versus 2.34 mm, P < 0,00015. Study results were of high heterogeneity (I^2 = 87.06% %, P <0.0001). The standardized mean difference in width preservation was 0.474 (95% confidence interval: -0.857 to 1.805, P=0.258) (**Figure IV**).

Alveolar ridge height preservation using xenograft

Four studies investigated the preservation of alveolar bone height after socket preservation using bovine derived xenograft. In the bovine derived xenograft subgroup[25,26,27,28] the effect of alveolar bone height preservation was greater than extraction alone (-1.53mm versus -2.34 mm, P < 0,0001) . Study results were slightly heterogeneous (I^2 = 10.74%, P = 0.3392). The standardized mean difference in alveolar ridge height preservation was 0.625 (95% confidence interval: 0.190 to 1.060, P= 0.005) (**Figure V**).

Alveolar ridge height preservation using alloplast

Only 2 studies researched alveolar ridge height preservation after extraction using synthetic alloplast.[27,28] The weighted mean average for this subgroup was 1.2 mm versus 2 mm in the control group, P=0,084. Study results were homogeneous, yet statistically insignificant (I^2 = 00.00% %, P = 0.9977). The standardized mean difference in height preservation was 0.541 (95% confidence interval: 0.0771 to 1.159, P= 0.084) (**Figure VI**).

Discussion:

Maintenance of socket width and height after tooth extraction has been of great clinical interest in scientific literature. It is mandatory to maintain the dimensions of the alveolar bone to achieve predictable and functional prosthetic restoration. Although, there has been advances made in guided bone regeneration, alveolar ridge preservation seems to be a less complicated and expensive procedure. This study shows suitable bone substitute must be chosen to prevent alveolar bone remodeling. The xenogenic bone substitutes proved to be more effective in the preservation of extraction sockets. It is noteworthy that socket maintenance procedure did not prevent bone resorption completely, thus reaugmentation of the extraction site might be necessary.[30] Socket preservation deals with a unique defect arrangement that is exposed to the mouth and makes difference of the graft material than in case of closed defects.[31]

The results of this article should be interpreted with caution due to its shortcomings. A small study pool is the

greatest weakness of this study. This is due to strict inclusion criteria regarding healing time, type of graft and outcome measurement. We recommend future researchers to conduct clinical trials in a more systematic fashion. Clinical studies should be designed to perform not only clinical (quantitative), but also histological (qualitative) assessment. It should be also taken into account that only quantitative data of alveolar ridge preservation was researched. To evaluate the quality of augmented bone, histomorphometric data must be collected. The proportionate amount of new bone, residual graft particles and bone marrow describes the value of grafted bone.[32] Nonetheless, conclusions can be drawn about alveolar ridge preservation using bovine derived xenograft.

Conclusions:

Within the limits of this study of clinical trials, the following conclusions were drawn:

1. Alveolar ridge preservation after extraction of incisor, canine and premolar teeth using bovine derived xenograft shows greater width and height preservation than no graft after 6 months.
2. The results for synthetic alloplast group were inconclusive, due to high heterogeneity and small number of included studies.
3. Less heterogeneous studies are needed to compare alloplastic bone grafts for socket preservation with a higher level of significance.

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