Socket preservation after tooth extraction : a systematic review
Mempertahankan soket setelah pencabutan gigi: tinjauan sistematik

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ABSTRACT
Objective: The aim of this study is to compare ridge dimensional and new bone formation after a socket preservation using different bone substitution material. **Methods**: This systematic study was conducted by reviewing the last five years dental articles that published from Pubmed and Wiley Online that focusing in socket preservation after tooth extraction. The articles were searched manually. There were 49 studies found, but only 4 studies met the inclusion criteria to be reviewed. **Result**: From 172 patiens as the subjects among the selected studies showed some changes in ridge dimensional insignificantly after the uses of bone substitution materials. Mean while, a significantly different new vital bone formation showed among studies. **Conclusion**: there is no difference of ridge dimensional changes between the bone substitution materials in the studies, but there is significantly difference new vital bone formation.
Keywords: socket preservation, bone subtitution materials, tooth extraction

ABSTRAK
Tujuan: Tujuan dari penelitian ini adalah untuk membandingkan dimensi tulang dan pembentukan tulang baru setelah mempertahankan soket dengan menggunakan bahan substitusi tulang yang berbeda. **Metode**: Penelitian sistematis ini dilakukan dengan meninjau lima tahun terakhir artikel gigi yang diterbitkan dari Pubmed dan Wiley Online yang fokus dalam upaya mempertahankan soket setelah pencabutan gigi. Artikel-artikel dicari secara manual. Ada 49 studi yang ditemukan, tetapi hanya 4 studi yang memenuhi kriteria inklusi. **Hasil**: Dari 172 pasien sebagai subjek di antara studi yang dipilih menunjukkan beberapa perubahan dalam dimensi lingir tidak signifikan setelah penggunaan bahan substitusi tulang. Sementara itu, pembentukan tulang vital baru yang sangat berbeda menunjukkan di antara studi. **Simpulan**: tidak ada perbedaan perubahan dimensi lingir antara bahan substitusi tulang dalam studi, tetapi ada perbedaan yang signifikan antara pembentukan tulang vital baru.
Kata kunci: preservasi soket, bahan subtitusi tulang, pencabutan gigi

INRODUCTION

The healing process of the alveolar ridge after tooth extraction has been described as a sequence of events including coagulum formation, progressively substituted by a highly vascularized granulation tissue, subsequently replaced by provisional matrix and later by woven bone. Finally, bone maturation will occur through bone remodeling processes and a mature spongiosa will be formed together a corticalization of the bony crest. The overall healing process leads to a decrease of the dimensions of the alveolar ridge that has been estimated to approach 50% of the its original width when analyzing the healing of sockets of premolars and molars 12 months after extraction.[1]

Natural healing of alveolar remodeling following tooth extraction include three dimensional bone remodeling and ridge atrophy after tooth extraction, bundle bone lining the extraction socket is resorbed.[2] Tooth extraction can induce significant changes to the residual alveolar ridge. These dimensional changes can significantly affect the alveolar ridge in both width and height. Extraction without ridge preservation can result in a mean height loss of 1.24 mm and mean width reduction of 3.79 mm as reported in a meta-analysis by Tan, et al.[3]

The cellular remodeling events result in clinically observed dimensional changes at premolar and molar sites, with up to 50% of the ridge width lost within 12 months following extraction.[4] The majority of this loss is observed within the first 3 months, and is slightly higher in mandibular molar regions.[1]

Following tooth extraction significant dimensional changes occur in the alveolar ridge. These dimensional changes can manifest as a loss of up to 50% of ridge width and height and occur rapidly following tooth extraction, typically within the first 6 months. Loss of alveolar ridge dimension occurs regardless of factors such as buccal plate thickness or tooth type. Loss of the alveolar bone is problematic for both clinicians and patients who desire dental implant therapy, as the

Table 1 Alveolar ridge dimensional changes

No	Titles	Groups	% Change in Ridge Width Mean ±SD	Change in ridge width (mm) mean±SD	Change in ridge height buccal (mm) Mean ±SD	Change in ridge height lingual (mm) mean ±SD
1	Effect of healing time on new bone formation following tooth extraction and ridge preservation with demineralized freeze-dried bone allograft. a randomized controlled clinical trial	Test Group (Short term Healing Group)	-13.93 ± 20.36	-1.41 ± 2.11	-1.82 ± 2.23	-0.84 ± 1.48
		Control Group (Long-term Healing Group)	-7.45 ± 16.58	-0.66 ± 1.55	-1.18 ±1.31	-0.84 ± 0.96
2	Histologic healing following tooth extraction with ridge preservation using mineralized freeze dried bone allograft alone versus a combined mineralized-demineralized freeze dried bone allograft.a randomized controlled clinical trial	Test Group (Combination)	-12.63 ± 14.55	-1.19 ± 1.36	0.26 ± 2.08	-0.80 ± 1.27
		Control Group (FDBA)	-17.93 ± 13.44	-1.63 ± 1.18	-0.25 ±1.85	-0.62 ± 1.78
3	Histologic evaluation of wound healing following ridge preservation with cortical, cancellous, and combined cortico-cancellous freeze-dried bone allograft. a randomized controlled clinical trial	Test Group (50/50% Cortico-cancellous)	-9.37 ± 11.08	-0.90 ± 1.08	0.10 ± 1.64	-0.45 ± 1.69
		Control Group (100% Cortical)	-5.85 ± 15.16	-0.63 ± 1.34	0.29 ± 2.49	-0.63 ± 1.40
		Control Group (100% Cancellous)	-4.77 ± 11.64	-0.50 ± 1.12	-1.00 ± 1.51	-0.76 ± 1.34
4	Evaluation of healing following tooth extraction with ridge preservation using cortical versus cancellous freeze dried bone allograft	Cortical FDBA (N=15)	-15.19 ±11.81	-1.50 ±-0.25-2.00	-0.50 ± 0.00-1.00	-1.10 ±0.83
		Cancellous FDBA (N=17)	-20.41 ±16.18	-2.00 ±-1.00-2.50	-1.00 ±0.00-1.00	-1.94 ±1.37

remaining alveolus may not be suitable for placement of a dental implant in an appropriate restoratively-driven position and may require bone augmentation to reconstruct the ridge.[4]

After tooth extraction, alveolar ridge preservation is commonly performed immediately following. The goal of preservation is to minimize the dimensional changes of the ridge and to provide a sufficient volume of bone for dental implant placement. Many studies have shown the success of ridge preservation in minimizing loss of ridge when compared to control sites that were not treated with ridge preservation.[3]

Different systematic reviews have analyzed the effect of ARP on clinical and histological outcomes. The majority of the reviews concluded that ARP are effective in limiting horizontal and vertical ridge alterations. However, these procedures are not able to maintain completely the entire ridge volume. Moreover, it has not been possible to identify the superiority of any specific surgical techniques for ARP or the use of any specific grafting material.[1]

Alveolar ridge augmentation using bone grafts has allowed the placement of the implant in locations previously considered unsuitable or in more functional and esthetic positions.[5] Bone grafting for alveolar bone augmentation is currently considered a predictable and reliable procedure based on a number of previous experiment including Jung and colleagues' observation adjacent marginal bone level showed no radiographic difference after augmentation. Among various graft materials, autogenous bone is considered as the gold standard for its osteogenic potential. However, due to added morbidity and risk of complications from donor site, clinicians prefer commercially available non-autogenous graft materials.[3]

Many different biomaterials are used to reduce the dimensional changes following tooth extraction including autogenous, allogenic, xenograft, and alloplast. Due to the success in space maintenance, rapid bone turnover, biocompatibility, and the lack of need to harvest from another site, allograft materials have become increasing popular.[6]

Several different materials are available for use in ridge preservation procedures. Most commonly, allografts, xenograft, alloplastic and autogenous grafts are used today. While studies have shown success for several materials, freeze-dried bone allograft (FDBA) is a common choice among clinicians. FDBA

Table 2 Inclusion criteria

Search engine	Titles	Method	Base line	Materials	Vital bone formation	Subject	Site of socket	donor	Dimensional change
pubmed	Effect of healing time on new bone formation following tooth extraction and ridge preservation with demineralized freeze-dried bone allograft. a randomized controlled clinical trial	Clinical measurements Histomorphometric analysis	8-10 weeks	DFDBA	32.63	44 patiens	Non molar	42 years old male	no difference
			18-20 weeks	DFDBA	47.41				
pubmed	Histologic healing following tooth extraction with ridge preservation using mineralized freeze dried bone allograft alone versus a combined mineralized-demineralized freeze dried bone allograft. a randomized controlled clinical trial	Histomorphometric analysis	18-20 weeks	M-D DFDBA	36.16	42 patiens	Non molar	64 aged male	no difference
				MFDBA	24.69				
pubmed	Histologic evaluation of wound healing following ridge preservation with cortical, cancellous, and combined cortico-cancellous freeze-dried bone allograft. a randomized controlled clinical trial	histomorphometric analysis	18-20 weeks	combinati FDBA	26.40	66 patiens	Non molar	72 years old male	no difference
				Cortical FDBA	24.54				
				Cancellous FDBA	28.81				
wiley	Evaluation of healing following tooth extraction with ridge preservation using cortical versus cancellous freeze dried bone allograft	Histomorphometric analysis	17-21 weeks	Cortical FDBA	16.08	20 patiens	Non molar	68 years old male	no difference
				cancellous FDBA	12.98				

has performed similarly when compared to gold standard autogenous grafts and has outperformed alloplastic materials regarding dimensional stability and new bone formation. Benefits of FDBA also include low-cost, unlimited supply and lack of a secondary surgical site.[5]

Demineralized FDBA or DFDBA and mineralized FDBA are commonly used products that are well supported by current data to reduce change in ridge dimension following tooth extraction and to provide adequate new vital bone for implant placement. FDBA maintains socket space and acts as a scaffold for host osteoprogenitor cells during the healing phase.[7]

Beck and Mealey allowed ridges to heal after extraction and ridge preservation with a mineralized allograft for 3 months and 6 months. Histologically, there was no difference in new vital bone formation between 3 and 6 month post-extraction healing period, suggesting that implant placement at either time point would be appropriate. Few studies have histologically evaluated the healing of ridge preservation grafts at differing time points.[7]

The aim of this systematic review is to study the difference in healing following tooth extraction and ridge preservation using difference materials at a healing time point of 18-20 weeks. This study is also reviews histologically compare the amount of new bone formation, residual graft material. Secondary objectives include comparing dimensional changes in ridge height and width following tooth extraction and ridge preservation with difference substitution materials from the last five years dental articles that published from Pubmed and Wiley Online that focusing in socket preservation after tooth extraction.

Histologic Analysis

No	Titles	Groups	Vital Bone (%) Mean +SD	Residual Graft (%) Mean +SD	CT/Other (%) Mean +SD	Significant
1	Effect of Healing Time on New Bone Formation Following Tooth Extraction and Ridge Preservation With Demineralized Freeze-Dried Bone Allograft. A Randomized Controlled Clinical Trial	Test Group (Short-term Healing Group)	32.63 ± 21.45*	37.42 ± 18.53†	29.94 ± 17.51	*P=0.012 for test group versus control †P=0.059 for test group versus control
		Control Group (Long-term Healing Group	47.41 ± 11.66*	26.80 ± 15.20†	25.78± 13.82	
2	Histologic Healing Following Tooth Extraction With Ridge Preservation Using Mineralized Freeze Dried Bone Allograft Alone Versus a Combined Mineralized-Demineralized Freeze Dried Bone Allograft. A Randomized Controlled Clinical Trial	Test Group (Combination)	36.16 ± 11.91*	18.24 ± 12.47†	45.38 ± 11.09	*P=0.0116 for test group versus control †P=0.0350 for test group versus control
		Control Group (FDBA)	24.69 ± 15.92*	27.04 ± 13.62†	48.27 ± 14.16	
3	Histologic Evaluation of Wound Healing Following Ridge Preservation With Cortical, Cancellous, and Combined Cortico-Cancellous Freeze-Dried Bone Allograft. A Randomized Controlled Clinical Trial	Test Group (50/50% Cortico-cancellous)	26.40 ± 13.18	23.37 ± 12.49	50.23 ± 11.52	* P = 0.04 for % Residual Graft in 100% Cortical vs. other groups No significant difference between groups for any other measurements (P>0.05)
		Control Group (100% Cortical)	24.54 ± 8.65	28.14 ± 10.66*	47.32 ± 10.83	
		Control Group (100% Cancellous)	28.81 ± 14.09	18.82 ± 8.44	52.37 ± 10.29	
4	Evaluation of Healing Following Tooth Extraction With Ridge Preservation Using Cortical Versus Cancellous Freeze Dried Bone Allograft	Cortical FDBA (N=16)	16.08 (12.12-30.25)	28.38 (18.47-37.52)	52.90 (47.40-57.08)	P value 0.857 0.019 0.040
		Cancellous FDBA (N=17)	12.98 (10.06-31.04)	19.94 (15.82-24.33)	62.82 (50.89-68.51)	

METHOD

This systematic study was conducted by reviewing dental articles that published in dental journals from April 2014 until November 2018 on Pubmed and Wiley Online that focusing in socket preservation after tooth extraction. Specific keywords were used to identify the appropriate studies need. The articles were searched manually and selected manually too with inclution criteria. There were 49 studies found. Only full text articles that studies in human that using histologic and dimensional changes evaluation study that was review in this studies. From the inclusion criteria there only 4 studies met to be reviewed.

RESULT

The data base search yielded 49 references, including 19 from PubMed and 30 from Wiley. There were 7 studies from PubMed and 5 studies from Wiley that full text published were reviwed. There were 2 duplicate studies removed and 10 studies remained. The titles and abstracts were reviewed afterward. The full-texts then be reviewed by the investigators and yielded 4 articles which met the inclusion criteria.

All articles that met the inclusion were reviewed. A total 172 patiens were subjected as a studies showed insignificantly changes in ridge dimentional after the uses of bone substitution materials. Mean while, a significantly different new vital bone formation showed among studies.

In the studies using DFDBA as a bone substitution materials showed trend of greater new vital bone formation. There was 47.41% vital bone formation in the used of DFDBA alone in socket preservation after 18 weeks evaluation. In other studies using 70:30% of mineralized : demineralized FDBA produced increased vital bone formation 36.16% compare to FDBA 24.69%. Even in 9 weeks evaluation, the vital bone formation 32.63% showed trend of greater new vital

CONCLUSION

No	Title	New Vital Bone Formation		Ridge Dimensional Changes		Materials
1.	Effect of Healing Time on New Bone Formation Following Tooth Extraction and Ridge Preservation With Demineralized Freeze-Dried Bone Allograft. A Randomized Controlled Clinical Trial	9 weeks	19 weeks	9 weeks	19 weeks	DFDBA
		significantly lower	significantly greater	there is no difference	there is no difference	
2.	Histologic Healing Following Tooth Extraction With Ridge Preservation Using Mineralized Freeze Dried Bone Allograft Alone Versus a Combined Mineralized-Demineralized Freeze Dried Bone Allograft. A Randomized Controlled Clinical Trial	significantly lower		there is no difference		Cortical mineralized FDBA
		significantly greater		there is no difference		COMBINATION
3.	Histologic Evaluation of Wound Healing Following Ridge Preservation With Cortical, Cancellous, and Combined Cortico-Cancellous Freeze-Dried Bone Allograft. A Randomized Controlled Clinical Trial	there is no difference		there is no difference		100%Cortical FDBA
		there is no difference		there is no difference		100%Cancellous FDBA
		there is no difference		there is no difference		Combination 50% /50%
4.	Evaluation of Healing Following Tooth Extraction With Ridge Preservation Using Cortical Versus Cancellous Freeze Dried Bone Allograft	there is no difference		there is no difference		Cortical FDBA
		there is no difference		there is no difference		Cancellous FDBA

bone formation compare to FDBA in other studies after 18 weeks evaluation.

DISCUSSION

The ridge preservation procedure has proven to have a high degree of success in preserving ridge dimensions when compared to non-ridge preserved controls and ridge preservation may reduce the need for additional bone augmentation during implant placement.[4,5] Allogenic freeze-dried bone has been shown to have excellent osteoconductive properties, permitting a balance of dimensional stability and revascularization for vital bone deposition.[4] The use of custom plastic stents permitted standardized measurements to be recorded at each time point. The ridge preservation procedures produced favorable horizontal and vertical dimensional stability of the alveolar ridge compared to non-ridge preservation.[5]

Both allograft FDBA and DFDBA produced favorable clinical results that were superior to recent studies evaluating tooth extraction without alveolar ridge preservation. Based on the results of this study, there is no difference in alveolar ridge changes when ridge preservation procedures are performed with mineralized FDBA alone compared to a combination of mineralized and demineralized FDBA. Interestingly, there was no correlation between initial buccal plate thickness and ridge width changes during the 18-20 week post-extraction healing period. This finding questions the recommendation of clinicians who propose that alveolar ridge preservation is only indicated in sites with thin buccal plates.[4]

Many different types of materials have been used for ridge preservation and have shown various degrees of success. A graft material that promotes a high percentage of new vital bone is beneficial for implant placement and stability.[8] Borg and Mealey compared ridge preservation with a 100% mineralized FDBA allograft to a combination allograft with a ratio of 30% DFDBA/70% FDBA at 19 weeks of healing.[12] The donor inductivity score for the graft material in that study was graded as 3 of 4, and the mean new vital bone formation was 36.16% in the combination allograft group. This was significantly more new bone formation compared to the group grafted with FDBA alone (24.7%) and very similar to the 32.43% new vital bone formation from Wood and Mealey's[11] study using 100% DFDBA. It is possible that the higher inductivity of the DFDBA in the Borg and Mealey[12] study resulted in induction of new vital bone formation equivalent to that in the Wood and Mealey[11] study despite that the demineralized allograft made up only

30% of the graft material used in the former study compared to 100% DFDBA used in the latter. In considering these studies and the current study, DFDBA results in significantly greater formation of new vital bone after ridge preservation compared to FDBA.[7]

The rationale using of DFDBA as an material of osteoinductive has been described numerous times in the literature. The osteoinductive character of the material relies on the presence of BMPs within the sample.[16]Evidence illustrates that not all commercially procured lots of DFDBA are osteoinductive, and the nature of their osteoinductive capacity relies on the age of the donor as well as BMP within the sample following processing. In order to confirm the osteoinductive capacity of a given sample it must undergo adequate testing prior to implantation. DFDBA alone has been shown to be superior to natural healing when evaluating ability to form vital bone in alveolar ridge preservation. In contrast the use of FDBA as an osteoconductive scaffold for new bone formation allows for both space maintenance and clot stability during healing.[4]

The higher new vital bone formation on the studies from Whetman and Mealey 47.41% also has corelation with the age of the donor, 42 years old male.[7]

It is concluded that there were significant ridge dimensional change between preserved and non preserved socket after extraction using DFDBA or FDBA materials, but there were no significant ridge dimensional change compere both materials. There were significant new vital bone formation when using DFDBA compere to FDBA as a bone substitution materials for socket preservation prosedure.

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