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International Journal of Current Research in Life Sciences
Vol. 07, No. 03, pp.1320-1323, March, 2018

ISSN: 2319-9490

RESEARCH ARTICLE

BIOACTIVE GLASS IN SINUS LIFT PROCEDURES: A SYSTEMATIC REVIEW

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Received 05th January, 2018; Accepted 24th February, 2018; Published Online 30th March, 2018

ABSTRACT

The aim of this review was to evaluate literature on the efficacy of bioactive glass as a grafting material in sinus floor augmentation. The main advantage of bioactive glass is the avoidance of a second surgical site needed for the harvest of autogenous bone. A PubMed search was carried out, limited to human studies for articles on bioactive glass as a grafting material sinus lift procedures. 17 unique results were found. 10 results met our inclusion criteria. All the studies were analyzed for sample size, case-selection criteria, surgical technique, evaluation criteria, success rates and follow-up period. Bioactive glass showed promising results as a grafting material and is a relevant material for natural bone regeneration. There is adequate literature support for its use with or without autogenous bone as a graft for sinus augmentation.

Key words: Bioactive Glass, Sinus Augmentation, Sinus Lift, Alloplast, Bone Regeneration.

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Citation: Dr. Vasundhara Prakash and Dr. Deborah Sybil, 2018. "Bioactive glass in sinus lift procedures: A systematic review" *International Journal of Current Research in Life Sciences*, 7, (03), 1320-1323.

INTRODUCTION

Edentulous patients with severely resorbed maxillae suffer from poor retention of prosthesis (Tadjoedin etal, 2000).Implants can provide retention to the prosthesis but it is challenged and complicated by unfavorable post extraction bone pattern, pneumatization of maxillary sinus resulting in poor quality of remaining alveolar bone(Misch, 1999). Maxillary sinus augmentation helps to restore ideal bone height and volume for implant stabilization (Yildirim *et al.,* 2001, Tadjoedin *et al.,* 2002). Various graft materials such as autogenous grafts, allogenousgrafts, xenografts, and synthetic grafts are used in bone regeneration (Scarano, 2006).However it is not established which of these materials except for autogenous bone (AB) provide better osteogenic potential and biochemical properties. Use of AB has limitations as it creates donor site morbidity and need secondary operation (Cordioli *et al.,* 2001). Therefore a need has been expressed for an ideal biomaterial that is biocompatible, promotes osteogenic cell attraction, joins the host bone without intermediary fibrous tissue, shares forces with host bone, is degradable, non-antigenic, and sterilizable (Jones, 2013). Bioactive glass (BG), a bioactive ceramic developed by Lary Hench is reported to have all the necessary characteristics (Jones, 2013;Hench, 2006). It has been used in root apical resections, extraction sites, periodontal defects, and orbital reconstructions (Clozza *et al.,* 2014; Dybvik, 2007;Kinnunen *et al.,* 2000; Throndson *et al.,* 2002).

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BioGran, a commercial form of BGceramic of particle size 300-355µm has shown promising results (Tadjoedin *et al.,* 2000;Cordioli *et al.,* 2001;Furusawa *et al.,* 1997;Turunen *et al.,* 2004).In this systematic review we aim to investigate the role of BG in sinus augmentation procedure.

MATERIALS AND METHODS

Study design

Studies which used bioactive glass for sinus lift procedure in humans were included in this review. Studies comparing other materials with BG as sole grafting material and/or as an adjunct were also included. Knowledge reports, animal studies and review articles were excluded.

Search strategy

An electronic search of literature in PubMed was carried out in February 2018, limited to English-language and human studies using a combination of following key words: bioactive glass, alloplastic material, ridge augmentation, sinus augmentation, sinus lift and dental implant. No publication year limitation was applied. A total of 17 search results were returned. Primary selection of titles and abstracts was based on inclusion criteria. Full texts of all eligible studies were obtained and reviewed by the authors. Manual search of the references of the eligible articles was done to obtain articles which met the inclusion criteria.

Table 1. Summary of Reviewed Articles

S.No	Author	Type of study	No. of patients	Type of BG and control (if any)	Evaluation Criteria	Results	Follow-up
1.	Furusawa *et al.,* 1997	CS	25	BioGran	1.Histology 2.Elemental composition and distribution by electron probe micro analyzer 3.Biomechanical	Bone formation in all cases Biomechanical properties similar to bone	6 months
2.	Leonrtti *et al.,* 2000	CR	3	300-355µm	Clinical (successful implant placement)	Adequate bone formation	6 months
3.	Tadjoedin *et al.,* 2000	CS	10 (age range 48-60yr)	1:1 BG and AB	1.Tetracycline labelling 2.Qualitative Histology 3.Bone histomorphometry	Lamellar bone volume – 45%	16 months
4.	Cordioli *et al.,* 2001	CR	12 (age range 35-63yr)	4:1 BG and AB	1.Clinially 2.Radiographically 3.Histology	Mean bone height gain of 7.1+ 1.6 mm Bone volume – 30.6+5.7%	12 months
5.	Tadjoedin *et al.,* 2002	CS	3 (age range 49-74yr)	80-100% BG with 0-20% AB	Histology	Bone volume – 42% Healing time – 6-12 months	15 months
6.	Turunen *et al.,* 2004	CS	17 (age range 39-70yr)	1:1 BG (800-1000µm S53P4) and AB	1.Histology 2.Energy dispersive analysis 3.SEM imaging	Bone volume – 34% Thicker bony lamellae in BG than in AB	62 weeks
7.	Jodia *et al.,* 2014	CR	12(age range 20-50yr)	BG putty	1.Clinically 2.Radio graphically	Increase in residual ridge height – 71.43 to 133.33%	30 months
8.	Abdulkarim H et al	CR	36	BG	Clinical Radiological	BG volume reduction – 24.6%	6 months
9.	Pereira *et al.,* 2017	CS	30	1:1 BG and AB	1.Histomorphometric analysis 2.Immunochemical analysis	New bone formation – 45.6+ 13.5% (BG alone) 45.8+13.9% (BG:AB) 39.9+15.8% (AB alone)	6 months
10.	Pereira *et al.,* 2017	CS	29	1:1 BG and AB	1.CBCT 2.MicroCT	Volumetric changes: 44.2% (BG alone) 37.9% (BG:AB) 45.7% (AB alone)	6 months

CS- Case series, CR- Case report, BG – Bioactive glass, AB – Autogenous bone

RESULTS

Of the 17 articles obtained from the search engine, 4 articles were animal studies, 2 articles were reviews, 2 were knowledge reports and 1 was on use of BG in ridge augmentation in mandible. 8 articles met the inclusion criteria. Manual search of the references of the 8 eligible articles yielded 2more studies which met the inclusion criteria. Finally 10 articles have been reviewed by the authors (Table 1).

DISCUSSION

Sinus augmentation is a procedure to increase vertical height for implant placement. Various materials have been used for sinus lift like autogenous grafts (Hirsch & Ericsson 1991; Lundgren *et al.,* 1996), freeze dried bone allografts (Smiler *et al.,* 1992; Nishibori *et al.,* 1994), hydroxyapatite (Wagner 1991; Moy *et al.,* 1993; Wheeler *et al.,* 1996), and xenografts (Smiler *et al.*1992; Valentini & Abensur 1997).However it is not established which of these materials except autogenous bone (AB) provides better osteogenic potential. Though AB is considered 'gold standard' for osseous reconstruction, it presents with practical difficulties like secondary surgery, morbidity of the donor site, need for general anesthesia (Browaeys *et al.,* 2007). Bioactive glass(BG)an alloplastic bone graft material has been used as a bone substitute in periodontal and osseous reconstructive procedures (Schepers *et al.,* 1991; Schepers *et al.,* 1993; Wilson *et al.,* 1993; Furusawa & Mizunuma 1997; Low *et al.,* 1997; Schepers & Ducheyne 1997), in alveolar filling and in apical resections (Throndson RR, 2002). BG is biocompatible and nontoxic. It has osteoconductive and osteostimulative properties. It has the ability to chemically bind with bone and has shown bone regenerative activities.

BioGran one of the commercial forms of BG is composed of 45% SiO_2, 24.5% CaO, 24.5% NaO_2, and 6% P_2O_5 (Schepers *et al.,* 1997). It has been used in form of large particles and blocks in various studies (Hench & Paschall 1973). However particles in size range 300-355µm are most useful in sinus liftas their outer shell becomes cracked at 4 months after grafting at the site. Silica starts to disappear from the center and new bone formation starts taking place in the central excavated part by undifferentiated mesenchymal cells which in grows from loose connective tissue. These cells completely surround the granules and form osteoblasts which start bone formation. Islands of newly formed bone function as nuclei for further bone repair (Tadjoedin *et al.,* 2000).8 out of the 10 studies we reviewed have used BG of size range 300-355µm (BioGran). One study used BG of 800-1000 µm (Turunen *et al.,* 2004) and the other used BG putty (Jodia *et al.,* 2014). Concentration of BG in the graft material has a significant role in the success of bone regeneration in atrophic maxillary posterior region. The most preferred concentration is a 1:1 ratio of BG and AB. 4 of the studies we reviewed used a 1:1 combination and have found adequate bone formation with respect to bone volume (Tadjoedin *et al.,* 2000) and new bone formation (Pereira RS *et al.,* 2017). A higher concentration of BG has shown increased bone height in 3 of the studies we reviewed (Cordioli *et al.,* 2001; Tadjoedin *et al.,* 2002; Jodia *et al.* 2014). Cordioli *et al.,* (2000) suggested the use of BG granules mixed in a 4:1 ratio with AB and obtained a bone height gain of 7.1+1.6 mm. Tadjoedin *et al* (2002) suggested a mixture of 80-100% BG with 0-20% AB and obtained a bone volume of 45% in the posterior maxilla. It is unclear whether the increased bone height is due to new bone formation or persistence of unresorbed BG. Presence of a control group in a study produces reliable results. 6 of the studies we reviewed have compared BG with AB and a mixture of both.

These studies have compared not just bone height gained but also new bone formation and healing time. These studies also state that increasing the concentration of BG in the graft increases the healing time. In cases where BG was used a sole grafting material, the healing time was as late as 12 months. Pereira RS *et al.,* (2017) compared new bone formation and cellular behavior of BG alone, a 1:1 combination of BG: AB and AB alone by immnohistochemical assessment. 30 patients were divided into 3 groups. Group 1 was grafted with BG, Group 2 with 1:1 mixture of BG: AB and Group 3 with AB alone. Results demonstrated BG in combination with AB (group 2) showed highest percentage of bone formation i.e. 45.8 ±13.9% followed by group 1(45.6±13.5%) and group 3(39.9±15.8%). The particle size of BG has an important role in success of the graft as the available surface area of BG is significant for new bone formation around it. All the studies we reviewed used BG of 300- 355um except for the study by Turunen *et al.* (2004) where the authors used BG granules of size 800-1000um. The authors suggest that BG of larger particle size maintains volume of the newly formed bone and dissolutes at a slower rate as compared to BG of smaller particle size.

Conclusion

Bioactive glass particles are acceptable alternatives to the use of autogenous bone grafts in maxillary sinus augmentation procedures. There is adequate literature support in the form of clinical trials for the use of BG of size range 300-355um in bone regeneration in maxillary posterior region.

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