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Open sinus lift surgery and augmentation with (SCPC versus H.A): A systematic review

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ABSTRACT

Keywords: Bone augmentation Silica calcium phosphate nanocomposite (SCPC) Hydroxyapatite Open sinus lift surgeries

Open sinus lift is used to augment the maxillary sinus prior to implant placement in patients with sinus pneumatization due to early extraction of upper molars. Where the remaining available bone length is from zero to 6 mm which will not accommodate for implant placement and not sufficient for implant initial stability so we will need to do Sinus lift and augmentation of the sinus with various bone grafts either (alloplast, allograft, Autogenous). Search is conducted electronically on line in pub med & Cochrane and manual Search was also done from 2007 to 2018, the articles included assisting &evaluating various types of bone substitute used in open sinus lift surgeries. 197 papers are identified through data base searching 37 Additional records identified through manual search, after duplication removal the remaining papers are 187, 187 paper were reviewed & 152 were excluded by title &abstract, 35 article were reviewed as full text, 27 articles were excluded by reason, 8 articles were included in this study, Eight included articles have revealed new bone formation with percentage ranges from 48% as the highest percentage & 16.4 as the lowest percentage, residual material ranges from 6.3% to 34.8% which differs according to type of bone graft used, histological evaluation is performed in 7 articles in addition to radiological evaluation only one article used radiographic evaluation only. This systematic review supported the fact that bone substitute act as a scaffold for new bone formation with different percentages according to type of bone substitute used.

1. Introduction

After extraction of teeth in posterior maxilla alveolar bone resorption takes place as well as maxillary sinus pneumatization results in bone loss. Long term survival and success of dental implant requires primary stability and appropriate bone volume [1]. It was clearly demonstrated that implants placed in poor bone quality have higher failure rates than implant placed in higher bone quality [2,3]. Implants placed in posterior region of maxilla showed the lowest success. The poorest bone density exists in posterior region of the maxilla therefore it is associated with the highest failure rates [3,4]. Misch has revealed that bone density of the implant bed is an important factor in determining the treatment plan; implant design, surgical approach, healing time and initial progressive bone loading during prosthetic reconstruction.

He classified bone density: D1: Dense cortical bone. D2: Thick dense to porous cortical bone on the crest and coarse trabecular bone within. D3: Thin porous cortical bone on the crest and fine trabecular bone within. D4: Fine trabecular bone. D5: Immature, non-mineralized bone [5,6]. Bone quality is classified into 4 categories according to lecholm and zarb [7]. Type I: composed of homogenous compact bone. Type II: composed of thick layer of compact bone surrounding a core of dense trabecular bone. Type III: composed of thin layer of cortical bone surrounding dense trabecular bone. Type IV: composed of a thin layer of cortical bone surrounding a low density core of trabecular bone. Gaffin and Berman reported 55% of all implant failure occurred in type IV bone [8]. Increasing bone volume in posterior maxilla and bone quality has been achieved by combining various procedures and materials [9]. Elevation and augmentation of the maxillary sinus can increase the bone height in the posterior area of the maxilla [10].

At the Consensus Conference on Maxillary Sinus Elevation in 1996 [11] the members made the following recommendations which depend on the residual bone height (RBH):

- Category A (RBH ≥ 10 mm): classic implant procedure
- Category B (RBH ≥ 7–9 mm): osteotome technique with simultaneous placement of implants
- Category C (RBH ≥ 4–6 mm): maxillary sinus elevation with lateral access and bone graft and immediate or deferred placement of
implants

- Category D (RBH ≥ 1–3 mm): maxillary sinus elevation with lateral access and bone graft and deferred placement of implants

During the maxillary sinus floor elevation procedure, the space created between the residual maxillary ridge and the elevated Schneiderian membrane is usually filled with grafting material ([12] [13]). In this way, a bone fraction is created that may allow for reliable implant placement, either simultaneously with the elevation procedure when the residual ridge allows for primary implant stability or as a second stage after healing of the grafted site [14].

Bone grafting materials are generally classified as autografts, allografts, xenografts and alloplasts. Out of these, autografts harvested from the patient’s own body (chin, hip, ribs etc) are regarded “gold standard” [15,16]. Because of the lack of antigenicity of the graft material osteoconduction&osteoinduction. Allografts are transplants from a genetically non identical individual of same species which are “converted” to self by the host [16,17].

Xenografts are transplants from one species to another. Bovine derived bone is a good example of xenograft. Alloplasts are synthetic chemically derived bone substitute. Most often this material is a form of calcium phosphate. Although autograft material is currently the material of choice, there are limitations associated with its use, including donor site morbidity, limited donor bone supply, anatomical and structural problems, Band elevated levels of resorption during healing [18].

The use of allografts has the disadvantage of eliciting an immunological response due to genetic differences and the risk of inducing transmissible diseases [18,19]. Calcium phosphate ceramics and bioactive glasses were introduced more than 30 years ago as bone substitutes. These materials are considered bioactive because they bond to bone and enhance bone tissue formation.

The forms of calcium phosphate ceramics most widely used are tricalcium phosphate (B-TCP) and hydroxyapatite (HA). These materials have a similar structure to the mineral phase of bone and have been shown to be osteoconductive, i.e., enhance bone cells growth and direct bone deposition on their surfaces. The availability of HA and TCP in porous shapes has encouraged many investigators to evaluate the ability of these biomaterials to serve as tissue engineering scaffolds for cell and drug delivery.

However, there were setbacks. Hydroxyapatite is known to exhibit limited osteoconduction and has a slow rate of degradation in physiological solutions because of its chemical stability [20,21]. On the other hand, B-TCP is plagued by an unpredictable, fast rate of dissolution that may lead to an immunological response [22].

Bioactive glass (BG), which contains (45 wt %) of silica in addition to calcium and phosphorous, is known to have the most stimulatory effect on bone cell function [23,24].

Unfortunately, there is a limited opportunity to synthesize a porous BG and improve its mechanical and physicochemical properties without decrements in bioactivity.

Recently, a novel porous silica–calcium phosphate nanocomposite (SCPC) has been proposed as a candidate for bone tissue engineering scaffold. The new resorbable porous bioactive silica-calcium phosphate composite has the ability to absorb high quantities of serum protein and stimulate rapid bone generation. The high porosity of the SCPC enhanced cell colonization and bone formation on and within the graft material. The high rate of silica dissolution from SCPC promoted rapid bone regeneration and graft material resorption. Thermal treatment of the SCPC induced ion substitution and formation of solid solutions at significantly low temperature. These ultra structural modifications facilitated protein adsorption and controlled SCPC solubility [25,26].

It has been demonstrated that SCPC has a superior bone regenerative capacity and resorbability when compared to HA and bioactive glass.

The nanoporous structure, superior bioactivity, controlled dissolution kinetics, and strong stimulatory effect on osteoblast differentiation suggest wide applications of SCPC in the field of bone tissue reconstruction in maxillofacial surgeries.

The current study reviews the literature of application various types of bone substitute used for augmentation of the maxillary sinus by searching on Electronic Search engines are Pub Med and Cochrane. Manual search was done in the libraries of the Faculty of Oral & Dental Medicine, Cairo University; Faculty of Oral and Dental Medicine, Al-Azhar University; and the Faculty of Oral & Dental Medicine, Future University in Egypt.

2. Materials & methods

Publications on the subject were searched up to 2018 on electronic database (Cochrane & pub med) the keywords used are

1 'Sinus floor augmentation' [Mesh]
2 (((Calcium phosphate ceramics))) or ((Bioceramics)) and (Bone Augmentation)
3 (((Bone augmentation))) and (((Hydroxyapatite)))
4 (((Hydroxyapatite))) and (''Sinus floor augmentation'') Mesh

- The Manual search was done in the libraries of the Faculty of Oral & Dental Medicine, Cairo University; Faculty of Oral and Dental Medicine, Al-Azhar University; and the Faculty of Oral & Dental Medicine, Future University in Egypt.

2.1. Study selection

The PRISMA flow diagram in (Fig. 1) presents an overview of the selection process. The titles of identified reports were initially screened. The abstract was assessed when the title indicated that the study fulfilled the inclusion criteria. A full-text analysis was performed when the abstract was available or when the abstract indicated that the inclusion criteria were fulfilled. The references of the identified papers were cross-checked for unidentified articles.

Screening process showed in the prisma chart: two independent reviewers screened187 papers retrieved from electronic and manual search for possible inclusion in the review. 151 articles are excluded on the base of title and abstract. 27 articles are excluded on the base of exclusion criteria. 8 articles are included according to the inclusion criteria.

2.2. Study eligibility

- Inclusion criteria: randomized control trial or retrospective studies on open sinus lift and bone grafting. Adult, Medically Free, Sinus approximation 2-6 mm and In English
- The following exclusion criteria were applied: Pediatric, Medically Compromised, Invitro, Autogenous Graft, metanalysis.

3. Results

Initial search reviewed 197 paper from electronic search (pup med & Cochrane)&37 papers from manual search, 187 paper is present after filtration &duplication removal, 152 paper were excluded from title & abstract, remaining 35 articles were reviewed as full text articles, 27 paper were excluded according to the exclusion criteria, 8 articles were included in the study according to the inclusion criteria(Fig. 1) (Tables 1 and 2).

3.1. Reviewing & data extraction

Two independent researchers reviewed the selected 8 full text articles. 139 patients were included in all reviewed articles. The articles were analyzed as per overall study design and data mining of the articles included the collection of the following data: number of patients
in each article, age, gender, amount of residual alveolar bone (< 7 mm), type of graft used, time of implant placement and core bone biopsy retrieval and the amount of bone gain (as percentage or in millimeters).

Histological evaluation of newly formed bone showed 26.4% newly formed bone, 27.3% residual graft material, and 46.3% bone marrow in Kolerman et al. (2012) article [27]; while Stavropoulos A. et al. (2011) had an average of 28–31.8% newly formed bone, 6.3–16.5% residual graft, and the new bone was primarily woven and characterized by slender trabeculae and narrow osteoid zones, and in many instances bone was in contact with residual biomaterial particles [28]. On the other hand, Martinez et al. (2010) documented average newly formed bone of 35%, and residual graft of 32.6–34.8 ± 6.2–10.5%. Englrbert A et al. (2013) demonstrated 19–24% bone gain with a 19% residual bone [31]. Contrary to the reported high regenerated bone levels of 48% reported by Canullo L et al. (2009) after 6 months and 28% residual graft and 24% bone marrow. Histomorphometric analysis of different bone grafts by Susanna Annibali et al. (2014) reported newly formed bone ranging from as low as: 16.4% using mineralized solvent-dehydrated bone allograft (MSDBA) and as high as: 21.9% using equine bone (EB) [33]. On contrary, were the recent results of Claudio Stacchi et al. (2017) that demonstrated 34.9 ± 15% (NHA) 38.5 ± 17% (ABB) of vital bone and 20.6 ± 13% (NHA), ± 12% (ABB) of residual graft material & an overall 12 months loading success rate of 96.4% [34].

Radiographic studies as that of Jae-Kook Cha et al. (2011) reported sinus floor heights of a mean±std of 4mm±2 months with an insignificant loss of 0.83 ± 0.38 mm [29] while Kolerman et al. (2012) augmented sinus floor of remaining alveolar height of 5 mm up to 18 mm he used C.T scan to evaluate height in mm & area in mm² [27] englrbert A et al., 2013 reported increase in bone height ranges from 7.2 to 7.8 mm when sinus floor of less than 7 mm he used panoramic x ray for evaluation of bone height gain [31].

4. Discussion

Bone resorption following tooth extraction or due to advanced periodontal disease, and/or pneumatization of the maxillary sinus may result in insufficient bone in horizontal and/or more frequently, vertical dimension for the placement of dental implants in the posterior maxilla. Augmentation of the maxillary sinus floor (or sinus lift) with bone grafts and/or substitutes is nowadays a standard treatment approach for re-establishing an adequate bone volume in the posterior maxilla. Bone resorption following tooth extraction or due to advanced periodontal disease, and/or pneumatization of the maxillary sinus may result in insufficient bone in horizontal and/or more frequently, vertical dimension for the placement of dental implants in the posterior maxilla.

Prosthodontic rehabilitation through dental endosseous implants in the area of the posterior maxilla often fails due to an insufficient bone supply. To improve bone volume to support dental implants, tissue formation is commonly enhanced by autologous bone grafting, often combined with synthetic, resorbable materials.

In the present systematic review 8 articles were included according to the inclusion criteria, these articles were reviewed at which 139 patient were included in this review, these patients have open sinus lift procedure, with bone graft to augment the sinus followed by implant placement in a second surgery after a period from 3 to 6 months, radiological analysis were performed using C.B.C.T or C.T scan or pan-norama, during implant placement core bone biopsy were retrieved & analyzed either for histological and histomorphometric analysis, the sinuses for the 139 patients were augmented with various grafting materials.

7 articles have histological results in percentages for the newly formed bone & the amount of residual graft material, the highest level of bone gain was reported of 48% reported by Canullo L et al. (2009) after 6 months of grafting who used nanocrystalline hydroxyapatite silica gel [32] & the lowest level of bone gain was reported Susanna Annibali et al. (2014) reported newly formed bone of 16.4% using (MSDBA)
mineralized solvent dehydrated bone allograft [33], while the lowest amount of residual material was reported in Stavropoulos A. et al. (2011) which was 6.3% residual graft in the recombinant human growth factor and differentiation factor-5 coated tricalcium phosphate (rGDF-5/b-TCP)/4-month group [28] & the highest amount of residual material 34.8 ± 10.5.% for anorganic bovine-bone derived (ABB) reported by Martinez et al. (2010) [30].

So it is clear that the rate of new bone formation & the amount of residual material depends on the type of material used& its rate of resorption as the technique of sinus lift is similar in the patients included in the 7 articles & methods of histological evaluation is almost the same.

On the other hand radiographic evaluation was conducted in 2 articles beside the histological evaluation Kolerman et al. (2012) & (Engibert A et al., 2013) measured increase in height in term of mm. The increase in height ranges from 7 up to 18 mm [27,31].

While only one article used the radiographic evaluation without histological evaluation (Jae-Kook Cha et al., 2011) this study use Osteon, as a bone graft material, and to assess the height of the grafted material through radiographic evaluation. In this study the author used panoramic and intraoral films for evaluation of the rate of resorption of the grafted material this radiograph is a two dimensions tool which is not accurate to determine the rate of bone changes, the three dimension C.T scan is the recommended method for evaluation of bone changes [29].
<table>
<thead>
<tr>
<th>Article</th>
<th>Sample size</th>
<th>Gender</th>
<th>Age</th>
<th>Residual alveolar bone</th>
<th>Material used &amp; particle size</th>
<th>Time of implant placement</th>
<th>Outcome Measures (bone gain)</th>
<th>Device, Unit of measure</th>
<th>Study design</th>
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</thead>
<tbody>
<tr>
<td>Kolerman et al. [27]</td>
<td>12</td>
<td>5</td>
<td>7</td>
<td>42-80 years</td>
<td>5 mm HA- TCP 0.5-1 mm</td>
<td>9 months</td>
<td>6-18 mm 26.4% newly formed bone 27.3% residual graft</td>
<td>Height, Width (in mm) Area (in mm2)</td>
<td>Image J software Signal intensity</td>
</tr>
<tr>
<td>Stavropoulos A et al. [28]</td>
<td>31</td>
<td>16</td>
<td>15</td>
<td>41-65.9 years</td>
<td>5 mm rhGDF-5/b-TCP, β-TCP/AB</td>
<td>3-4 months</td>
<td>31.4% in the rhGDF-5/b-TCP, 28% in the rhGDF-5/b-TCP, 31.8% in the b-TCP/AB group. The proportion of remaining b-TCP averaged 12.6% in the rhGDF-5/b-TCP/3-month group, 6.6% in the rhGDF-5/b-TCP/4-month group, and 16.9% in the b-TCP/AB group.</td>
<td>Alizarin red stain using Image J software Signal intensity</td>
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<tr>
<td>Jae-Kook Cha et al. [29]</td>
<td>20</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>4-3 mm Osteon 0.5-1 mm-2 mm</td>
<td>6 months</td>
<td>30.81 ± 0.43 mm 10.85 ± 0.33 mm</td>
<td>mm</td>
<td>R.C.T</td>
</tr>
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<td>Martinez et al. [30]</td>
<td>16</td>
<td>-</td>
<td>38-67y</td>
<td>3.8 mm</td>
<td>ABB, TCP 1.6 ± 0.4 cm²</td>
<td>8 months</td>
<td>35% of new bone formed for both groups remaining presence of TCP particles was 32.6 ± 6.2% and 34.8 ± 10.5% for APP</td>
<td>Alizarin red stain using Image J software Signal intensity</td>
<td>mm</td>
</tr>
<tr>
<td>Engelbert A et al. [31]</td>
<td>12</td>
<td>-</td>
<td>36-73y</td>
<td>≤ 7 mm</td>
<td>βTCP 60% 0.7-1.4 mm, Resorbable collagenous membrane 25 × 25 mm</td>
<td>24% bone gain with membrane &amp; 19% without residual bone 19% (without membrane: 7.8 ± 1.9 mm; with membrane: 7.2 ± 1.5 mm; mean ± SD)</td>
<td>High resolution micro CT</td>
<td>mm</td>
<td>R.C.T</td>
</tr>
<tr>
<td>Canullo L et al. [32]</td>
<td>16</td>
<td>-</td>
<td>-</td>
<td>1-3 mm</td>
<td>nanocrystalline hydroxyapatite silica gel</td>
<td>48 ± 4.63% newly formed bone 28 ± 5.33% residual material</td>
<td>Alizarin red stain using Image J software Signal intensity</td>
<td>mm</td>
<td>R.C.T</td>
</tr>
<tr>
<td>Susanna Annibali et al., 2014</td>
<td>4 patients</td>
<td>3</td>
<td>1</td>
<td>mean age 52 years, range 36-70</td>
<td>Atrophied maxilla Less than 3 mm (HA-..-TCP 30/70), anorganic bovine bone (ABB), mineralized solvent-dehydrated bone allograft (MSDRA), and equine bone (EB)</td>
<td>After 6 months</td>
<td>30.2% newly formed bone for HA-..-TCP 30/70, 20.1% for ABB, 16.4% for MSDRA, and 21.9% for EB. Residual material (HA-..-TCP 30/70): 29.1% (ABB), 19.1% (MSDRA) 18.5%, (EB) 23.2%.</td>
<td>computerized tomography (CT) SCAN H.U Toulodine blue</td>
<td>R.C.T</td>
</tr>
<tr>
<td>Claudio Stacchi et al. [34]</td>
<td>28 patients</td>
<td>18</td>
<td>10</td>
<td>3-6 mm</td>
<td>Nanohydroxyapatite, anorganic bovine bone</td>
<td>6 months</td>
<td>Newly formed bone 34.9 ± 15% (NHA) 38.5 ± 17% (ABB) and residual graft 20.6 ± 13% (NHA) 22.3 ± 12% (ABB)</td>
<td>C.B.C.T. HU Toulodine blue</td>
<td>R.C.T</td>
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</table>
5. Conclusion

For the clinical point of view the present systematic review supported the fact that open sinus lift with grafting with bone substitute act as scaffold for a new bone formation leading to formation of new bone but we need further research on different types of bone grafts to improve its character and to improve the nature of the newly formed bone.

Conflicts of interest

No conflict of interest.

Disclosure statements

The authors declare that there are no financial or other conflicts of interest related to this publication.

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References