Maxillary Sinus Augmentation using Block Bone Grafts: A Systematic review

Master’s Thesis

Supervisor
Professor Gintaras Juodžbalys

Kaunas, 2019
Maxillary Sinus Augmentation using Block Bone Grafts: A Systematic review

Master’s Thesis

The thesis was done
by student .................................. Supervisor..................................
(Signature) .................................................................

.................................................. ..................................................
(name, surname, year, group) (degree, name, surname)

.............................................. 20..... .............................................. 20.....
(day/month) (day/month)

Kaunas ,2019
### EVALUATION TABLE OF THE MASTER’S THESIS
#### OF THE TYPE OF SYSTEMIC REVIEW OF SCIENTIFIC LITERATURE

**Evaluation:**

Reviewer:

(Scientific degree, name and surname)

Reviewing date: ........................................

<table>
<thead>
<tr>
<th>No.</th>
<th>MT parts</th>
<th>MT evaluation aspects</th>
<th>Compliance with MT requirements and evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Summary (0.5 point)</td>
<td>Is summary informative and in compliance with the thesis content and requirements?</td>
<td>0.3</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>Are keywords in compliance with the thesis essence?</td>
<td>0.2</td>
</tr>
<tr>
<td>3</td>
<td>Introduc- tion, aim and tasks (1 point)</td>
<td>Are the novelty, relevance and significance of the work justified in the introduction of the thesis?</td>
<td>0.4</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>Are the problem, hypothesis, aim and tasks formed clearly and properly?</td>
<td>0.4</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>Are the aim and tasks interrelated?</td>
<td>0.2</td>
</tr>
<tr>
<td>6</td>
<td>Selection criteria of the studies, search methods and strategy (3.4 points)</td>
<td>Is the protocol of systemic review present?</td>
<td>0.6</td>
</tr>
<tr>
<td>7</td>
<td></td>
<td>Were the eligibility criteria of articles for the selected protocol determined (e.g., year, language, publication condition, etc.)</td>
<td>0.4</td>
</tr>
<tr>
<td></td>
<td>Question</td>
<td>Score</td>
<td>Accuracy</td>
</tr>
<tr>
<td>---</td>
<td>--------------------------------------------------------------------------</td>
<td>-------</td>
<td>----------</td>
</tr>
<tr>
<td>8</td>
<td>Are all the information sources (databases with dates of coverage, contact with study authors to identify additional studies) described and is the last search day indicated?</td>
<td>0.2</td>
<td>0.1</td>
</tr>
<tr>
<td>9</td>
<td>Is the electronic search strategy described in such a way that it could be repeated (year of search, the last search day; keywords and their combinations; number of found and selected articles according to the combinations of keywords)?</td>
<td>0.4</td>
<td>0.1</td>
</tr>
<tr>
<td>10</td>
<td>Is the selection process of studies (screening, eligibility, included in systemic review or, if applicable, included in the meta-analysis) described?</td>
<td>0.4</td>
<td>0.2</td>
</tr>
<tr>
<td>11</td>
<td>Is the data extraction method from the articles (types of investigations, participants, interventions, analysed factors, indexes) described?</td>
<td>0.4</td>
<td>0.2</td>
</tr>
<tr>
<td>12</td>
<td>Are all the variables (for which data were sought and any assumptions and simplifications made) listed and defined?</td>
<td>0.4</td>
<td>0.2</td>
</tr>
<tr>
<td>13</td>
<td>Are the methods, which were used to evaluate the risk of bias of individual studies and how this information is to be used in data synthesis, described?</td>
<td>0.2</td>
<td>0.1</td>
</tr>
<tr>
<td>14</td>
<td>Were the principal summary measures (risk ratio, difference in means) stated?</td>
<td>0.4</td>
<td>0.2</td>
</tr>
<tr>
<td>15</td>
<td>Systemization and analysis of data (2.2 points)</td>
<td>0.6</td>
<td>0.3</td>
</tr>
<tr>
<td></td>
<td>Is the number of studies screened: included upon assessment for eligibility and excluded upon giving the reasons in each stage of exclusion presented?</td>
<td>0.6</td>
<td>0.3</td>
</tr>
<tr>
<td>16</td>
<td>Are the characteristics of studies presented in the included articles, according to which the data were extracted (e.g., study size, follow-up period, type of</td>
<td>0.6</td>
<td>0.3</td>
</tr>
<tr>
<td></td>
<td>Are respondents) presented?</td>
<td>Are the evaluations of beneficial or harmful outcomes for each study presented? (a) simple summary data for each intervention group; b) effect estimates and confidence intervals)</td>
<td>Are the extracted and systemized data from studies presented in the tables according to individual tasks?</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>17</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>Discussion (1.4 points)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>21</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>22</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>Conclusions (0.5 points)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>24</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>References (1 point)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>26</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>27</td>
<td>Is the scientific level of references suitable for Master’s thesis?</td>
<td>0.2</td>
<td>0.1</td>
</tr>
<tr>
<td>28</td>
<td>Do the cited sources not older than 10 years old form at least 70% of sources, and the not older than 5 years – at least 40%?</td>
<td>0.2</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td><strong>Additional sections, which may increase the collected number of points</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>29</td>
<td>Annexes</td>
<td>Do the presented annexes help to understand the analysed topic?</td>
<td>0.2</td>
</tr>
<tr>
<td>30</td>
<td>Practical recommendations</td>
<td>Are the practical recommendations suggested and are they related to the received results?</td>
<td>0.4</td>
</tr>
<tr>
<td>31</td>
<td></td>
<td>Were additional methods of data analysis and their results used and described (sensitivity analyses, meta-regression)?</td>
<td>1</td>
</tr>
<tr>
<td>32</td>
<td></td>
<td>Was meta-analysis applied? Are the selected statistical methods indicated? Are the results of each meta-analysis presented?</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td><strong>General requirements, non-compliance with which reduce the number of points</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>33</td>
<td>Is the thesis volume sufficient (excluding annexes)?</td>
<td>15-20 pages (-2 points)</td>
<td>&lt;15 pages (-5 points)</td>
</tr>
<tr>
<td>34</td>
<td>General requirements</td>
<td>Is the thesis volume increased artificially?</td>
<td>-2 points</td>
</tr>
<tr>
<td>35</td>
<td>Does the thesis structure satisfy the requirements of Master’s thesis?</td>
<td>-1 point</td>
<td>-2 points</td>
</tr>
<tr>
<td>36</td>
<td>Is the thesis written in correct language, scientifically,</td>
<td>-0.5 point</td>
<td>-1 points</td>
</tr>
<tr>
<td></td>
<td>Question</td>
<td>Points</td>
<td>Points</td>
</tr>
<tr>
<td>---</td>
<td>--------------------------------------------------------------------------</td>
<td>--------------</td>
<td>--------------</td>
</tr>
<tr>
<td>37</td>
<td>Are there any grammatical, style or computer literacy-related mistakes?</td>
<td>-2 points</td>
<td>-1 points</td>
</tr>
<tr>
<td>38</td>
<td>Is text consistent, integral, and are the volumes of its structural parts balanced?</td>
<td>-0.2 point</td>
<td>-0.5 points</td>
</tr>
<tr>
<td>39</td>
<td>Amount of plagiarism in the thesis.</td>
<td>&gt;20% (not evaluated)</td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>Is the content (names of sections and sub-sections and enumeration of pages) in compliance with the thesis structure and aims?</td>
<td>-0.2 point</td>
<td>-0.5 points</td>
</tr>
<tr>
<td>41</td>
<td>Are the names of the thesis parts in compliance with the text? Are the titles of sections and sub-sections distinguished logically and correctly?</td>
<td>-0.2 point</td>
<td>-0.5 points</td>
</tr>
<tr>
<td>42</td>
<td>Are there explanations of the key terms and abbreviations (if needed)?</td>
<td>-0.2 point</td>
<td>-0.5 points</td>
</tr>
<tr>
<td>43</td>
<td>Is the quality of the thesis typography (quality of printing, visual aids, binding) good?</td>
<td>-0.2 point</td>
<td>-0.5 points</td>
</tr>
</tbody>
</table>

**In total (maximum 10 points):**

*Remark: the amount of collected points may exceed 10 points.*

Reviewer’s comments: __________________________________________________________

_________________________________________    ___________________________
Reviewer’s name and surname    Reviewer’s signature
**TABLE OF CONTENTS**

1. ABSTRACT......................................................................................................................................... 10

2. INTRODUCTION................................................................................................................................ 11

3. SELECTION CRITERIA OF THE STUDIES. SEARCH METHODS AND STRATEGY.................................................................13

4. SYSTEMIZATION AND ANALYSIS OF DATA.............................................................................. 17

4.1. Retrospective cohort studies........................................................................................................ 23

4.2. Case series studies.......................................................................................................................... 24

5. DISCUSSION..................................................................................................................................... 23

6. CONCLUSIONS.................................................................................................................................. 29

7. REFERENCES.................................................................................................................................... 31
1. ABSTRACT

Objectives
The purpose of this study is to assess the reliability of bone block grafts in maxillary sinus augmentation procedures.

Materials and the methods
An electronic search was conducted using MEDLINE (PubMed) database, in order to find studies concerning sinus augmentation with the use of bone blocks. The search was restricted to English language with no restrictions regarding publication date.

Results
In total, 15 studies were reviewed in full, out of which 3 were excluded due to incompatibility with established inclusion criteria. The present study included 12 articles from which 3 were retrospective cohort studies and 9 were case series studies, the presented data included 672 patients and 1446 implants.

Conclusion
The findings of this study suggest that graft materials in block form have predictable outcomes in sinus augmentation procedures and that allograft blocks may be the best alternative over autograft blocks. However, long-term randomized controlled clinical trials comparing sinus augmentations with block bone grafts to other treatment modalities should be made in order to get a definitive confirmation on its efficacy and reliability.

Keywords: maxillary sinus, maxillary sinus floor augmentation, grafting bone, implant.
2. INTRODUCTION

Sinus floor augmentation is a surgical technique indicated in case of posterior maxillary bone height insufficiency when installation of endosseous implant is required [1-5]. A new compartment which is formed between the elevated sinus membrane and the maxillary sinus floor can be filled with different grafting materials such as autografts, allografts, xenografts, alloplasts, or a mixture of different graft materials in order to maintain space for a newly formed bone [6].

Autologous bone graft has been widely accepted as the gold standard technique due to its osteoconductive and osteoinductive properties as well as its regenerative osteogenicity [7, 8, 9]. However, autogenous bone has several drawbacks such as postsurgical pain, risk of paresthesia, and limitations in the quality and quantity of available bone [10, 11].

Nowadays bone grafting materials can be used in bone-block form or particulate form [12]. A surgical method, using an inlay autogenous bone graft, was first reported in 1980 by Boyne and James [13]. That report led to studies which were conducted using autogenous bone in block form [14-17]. Some of those studies [15-17] compared between block and particulate autogenous bone grafts and suggested that block form is preferable in several terms. One study [15] showed that using autogenous bone block grafts in maxillary sinus floor augmentation, is superior to autogenous particulate bone grafts in terms of bone healing around dental implants, while others [16, 17] suggested the usage of autogenous block graft over particulate graft in large maxillofacial bone reconstruction procedures taking into consideration future implant installation and to provide a more predictable 3d structure.

Nevertheless, harvesting autogenous bone is followed by increased donor site morbidity [18]. In the past few years maxillary sinus elevation was made using different methods, those techniques differ in type of graft material and the surgical technique. Sinus floor elevation using the block technique, or in particular an autologous bone block graft, has been reported to have an increase in tissue mineralization and new bone formation [19]. Additionally the block form bone graft can be adjusted to fit more optimally into the area of insufficient bone. However, large loss of bone volume can still occur during phase of remodeling even after using bone blocks [20].

The aim of this study is to review the literature for the outcomes of sinus augmentation using any type (autografts, allografts, xenografts, alloplasts) of bone block in order to assess the predictability of bone block grafts.
Our tasks are:

1. To evaluate the outcome of sinus augmentation procedures performed with bone blocks.
2. To determine which type of bone block graft material has the best outcome.
3. SELECTION CRITERIA OF THE STUDIES. SEARCH METHODS AND STRATEGY

Protocol

This systematic review was conducted following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement for systematic reviews.

Focus question

The focus question was developed according to PICO methodology:

- Population: patients with atrophic posterior maxilla with at least one premolar and/or molar missing
- Intervention: Sinus augmentation using block grafts and implant placement
- Comparison: a control group in which particulate bone graft was used or a group in which the sinuses were graft free
- Outcome: implant survival rate, peri-implant marginal bone loss (assessed radiographically), bone regeneration (radiologically and/or histologically) and complications.

Do sinus augmentation procedures performed with graft material in block form, have reliable outcomes?

Types of publications

The review included retrospective and prospective observational studies, case series that were published in English language on humans. Articles that were not published in English language, together with abstracts that were lacking full text, were excluded.

Types of studies

The review included any studies that presented with the relevant criteria.

Information sources

The information sources were the MEDLINE (PubMed) and EMBASE databases.

Population

Studies included human patients with posterior atrophic maxilla that were treated with sinus augmentation with any type of bone block graft, and dental implants.
Literature search strategy
An electronic search was conducted according to the PRISMA guidelines [21], using MEDLINE (PubMed) database, in order to find studies concerning sinus augmentation with the use of bone blocks. The key words that were searched included: “maxillary sinus augmentation” AND “bone blocks”. “Sinus” AND “graft” AND “bone block” AND “implant” AND “maxillary”. “Sinus lift” AND “block graft”. The search was restricted to English language, there were no restrictions on publication date.

Inclusion and exclusion criteria

Inclusion criteria for the selection

Full text articles which were possibly relevant were assessed for the following inclusion criteria:

- Studies in which sinus augmentation was performed with any type of block graft
- With either simultaneous or delayed implant placement
- Sinus augmentation was done with either lateral window or transcrestal approach
- Humans only
- Minimum follow up of 1 year
- At least one outcome evaluated in each study

Exclusion criteria for the selection

- Studies with insufficient information about the outcome of the procedure
- Sinus augmentation was performed with only particulated or putty grafts
- Studies in which sinus augmentation was performed without dental implantation
- Case reports (<4 patients) were excluded

Data extraction

Following the aim and the tasks of the study, data were extracted in the form of variables independently and are listed onwards as “data items”.

Data items

- “Author”-reveals authors name.
- “Year of publication”- revealed the year of publication
- “Number of patients”-revealed the number of patients.
- “Number of implants and/or blocks”-indicates number of implants positioned below sinus
- “Augmentation material” –indicates type of grafting material used for sinus augmentation
“Timing of dental implantation”-indicates whether dental implants were placed delayed or simultaneously
“Preoperative alveolar ridge height”-initial bone level and severity of atrophy
“Follow up period”-indicated period of follow up
“Implant survival”-primary outcome measure
“Marginal bone loss”-indicated loss of marginal bone
“Bone regeneration”-indicates either total augmentation at end of follow up or amount of bone height gain

Risk of bias across studies

In order to assess the quality of the studies and to identify studies with possible intrinsic errors that could affect the cumulative evidence, the Joanna Briggs Institute critical appraisal tools for use in JBI systematic reviews were used for both cohort and case series studies [22].

Bias parameters assessed for cohort studies:

1. Were the two groups similar and recruited from the same population? (Yes/No/Unclear/NA);
2. Were the exposures measured similarly to assign people to both exposed and unexposed groups? (Yes/No/Unclear/NA);
3. Was the exposure measured in a valid and reliable way? (Yes/No/Unclear/NA);
4. Were confounding factors identified? (Yes/No/Unclear/NA);
5. Were strategies to deal with confounding factors stated? (Yes/No/Unclear/NA);
6. Were the groups/participants free of the outcome at the start of the study (or at the moment of exposure)? (Yes/No/Unclear/NA);
7. Were the outcomes measured in a valid and reliable way? (Yes/No/Unclear/NA);
8. Was the follow up time reported and sufficient to be long enough for outcomes to occur? (Yes/No/Unclear/NA);
9. Was follow up complete, and if not, were the reasons to loss to follow up described and explored? (Yes/No/Unclear/NA);
10. Were strategies to address incomplete follow up utilized? (Yes/No/Unclear/NA);
11. Was appropriate statistical analysis used? (Yes/No/Unclear/NA);
Bias parameters assessed for case series studies:

1. Were there clear criteria for inclusion in the case series? (Yes/No/Unclear/NA);
2. Was the condition measured in a standard, reliable way for all participants included in the case series? (Yes/No/Unclear/NA);
3. Were valid methods used for identification of the condition for all participants included in the case series? (Yes/No/Unclear/NA);
4. Did the case series have consecutive inclusion of participants? (Yes/No/Unclear/NA);
5. Did the case series have complete inclusion of participants? (Yes/No/Unclear/NA);
6. Was there clear reporting of the demographics of the participants in the study? (Yes/No/Unclear/NA);
7. Was there clear reporting of clinical information of the participants? (Yes/No/Unclear/NA);
8. Were the outcomes or follow up results of cases clearly reported? (Yes/No/Unclear/NA);
9. Was there clear reporting of the presenting site(s)/clinic(s) demographic information? (Yes/No/Unclear/NA);
10. Was statistical analysis appropriate? (Yes/No/Unclear/NA);
4. SYSTEMIZATION AND ANALYSIS OF DATA

Study selection

The search strategy yielded 107 results in total (Figure 1), from which articles had their titles and abstracts independently screened, thus eliminating irrelevant publications. Initially 83 studies were excluded according title relevancy and later 24 abstracts were examined, from which 15 full text articles were assessed for eligibility according the inclusion and exclusion criteria. Finally, 12 articles have met the inclusion criteria and were included in this study.

Figure 1. PRISMA flow diagram of study selections

NCBI PubMed, database advanced search:

- Search terms:
  “Maxillary sinus augmentation” AND “bone blocks”.
  “sinus” AND “graft” AND “bone block” AND “implant” AND “maxillary”.
  “sinus lift” AND “block graft”.

- English language
- Studies on human

(n =107)

Abstracts examined
(n =24)

-Titles which were not relevant (n=83)

Full-text articles assessed for eligibility
(n =15)

-No access, full text articles were not available
(n =3)
-case reports (n=6)

Studies included in qualitative synthesis
(n =12)

- Retrospective cohort (n=3)
- Case series (n=9)

Full-text articles excluded with reasons (stated in study exclusion)
**Study exclusion**

Four full text articles [35-37] were excluded for the following reasons: In one article [35], it was revealed after full text assessment, that grafting material which was used in sinus augmentation was milled into particles before its placement to the sinus. In another study [36], sinus augmentation was performed with bone chips. Bone blocks were used for onlay grafting of posterior maxilla in both studies [35, 36] and not for sinus augmentation. One article was excluded because insufficient information regarding the clinical outcomes of block grafted areas [37].

**Quality assessment**

The quality assessment for the cohort studies [23-25] revealed low risk of bias (Table 1), while the assessment of case series studies [26-34] reviled unknown risk of bias (for one or more key domains) for all of the included studies (Table 2).
<table>
<thead>
<tr>
<th>Author</th>
<th>Were the two groups similar and recruited from the same population?</th>
<th>Were the exposures measured similarly to assign people to both exposed and unexposed groups?</th>
<th>Was the exposure measured in a valid and reliable way?</th>
<th>Were confounding factors identified?</th>
<th>Were strategies to deal with confounding factors stated?</th>
<th>Were the groups/participants free of the outcome at the start of the study (or at the moment of exposure)?</th>
<th>Were the outcomes measured in a valid and reliable way?</th>
<th>Was the follow up time reported and sufficient to be long enough for outcomes to occur?</th>
<th>Was follow up complete, and if not, were the reasons for loss to follow up described and explored?</th>
<th>Were strategies to address incomplete follow up utilized?</th>
<th>Was appropriate statistical analysis used?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Khoury et al. [23]</td>
<td>Yes</td>
<td>Na</td>
<td>Yes</td>
<td>Unclear</td>
<td>Unclear</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Na</td>
<td>Yes</td>
</tr>
<tr>
<td>Sbordone et al. [24]</td>
<td>Yes</td>
<td>Na</td>
<td>Yes</td>
<td>Unclear</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Na</td>
<td>Yes</td>
</tr>
<tr>
<td>Martuscelli et al. [25]</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Unclear</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Na</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Na=not applicable
Table 2. Quality assessment for case series studies.

<table>
<thead>
<tr>
<th>Author</th>
<th>Were there clear criteria for inclusion in the case series?</th>
<th>Was the condition measured in a standard, reliable way for all participants included in the case series?</th>
<th>Were valid methods used for identification of the condition for all participants included in the case series?</th>
<th>Did the case series have consecutive inclusion of participants?</th>
<th>Did the case series have complete inclusion of participants?</th>
<th>Was there clear reporting of the demographics of the participants in the study?</th>
<th>Was there clear reporting of clinical information of the participants?</th>
<th>Were the outcomes or follow up results of cases clearly reported?</th>
<th>Was there clear reporting of the presenting site(s)/clinic(s) demographic information?</th>
<th>Was statistical analysis appropriate?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chaushu et al. [26]</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Na</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Na</td>
<td>Na</td>
</tr>
<tr>
<td>Rizzo et al. [27]</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>unclear</td>
<td>Na</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Na</td>
<td>Na</td>
</tr>
<tr>
<td>Rocha et al. [28]</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Na</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Na</td>
<td>Na</td>
</tr>
<tr>
<td>Rizzo et al. [29]</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Na</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Na</td>
<td>Na</td>
</tr>
<tr>
<td>Zvi Artzi et al. [30]</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Na</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Na</td>
<td>Na</td>
</tr>
<tr>
<td>Sindel et al. [31]</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Na</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Na</td>
<td>Na</td>
</tr>
<tr>
<td>Eurico et al. [32]</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Na</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Na</td>
<td>Na</td>
</tr>
<tr>
<td>Mangan et al. [33]</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Na</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Na</td>
<td>Na</td>
</tr>
<tr>
<td>Isidori et al. [34]</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Na</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Na</td>
<td>Na</td>
</tr>
</tbody>
</table>
Study Characteristics

Out of all the included articles [23-34], 3 were Retrospective cohort studies [23-25] which included a total of 246 patients and 517 implants. The rest of the included studies were case series studies [26-34] and included a total of 672 patients and 1446 implants.

Table 3. Study Characteristics

<table>
<thead>
<tr>
<th>Author</th>
<th>Year of publication</th>
<th>Total number of patients who underwent augmentation</th>
<th>Total number of implants (positioned into block grafted sinuses)</th>
<th>Type of augmentation bone block</th>
<th>Timing of dental implantation</th>
<th>Implant survival/ success rate (%)</th>
<th>Preoperative alveolar ridge height (mm)</th>
<th>Follow up period after implant loading (y\m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Khoury et al. [23]</td>
<td>1996</td>
<td>74 males and 142 females</td>
<td>467</td>
<td>Autogenous from symphysis or retromolar region</td>
<td>Simultaneous</td>
<td>439 were osseointegrated</td>
<td>1-5mm</td>
<td>6 years</td>
</tr>
<tr>
<td>Sbordone et al. [24]</td>
<td>2014</td>
<td>14</td>
<td>13</td>
<td>Autogenous iliac bone or FDBA</td>
<td>Delayed</td>
<td>No failure was recorded</td>
<td>nd</td>
<td>1.5 years</td>
</tr>
<tr>
<td>Martuscelli et al. [25]</td>
<td>2014</td>
<td>16</td>
<td>37</td>
<td>Autogenous or ungrafted</td>
<td>Delayed</td>
<td>Ungrafted- 87% Autograft- 100%</td>
<td>-</td>
<td>5 years</td>
</tr>
<tr>
<td>Case series</td>
<td>Year</td>
<td>Number</td>
<td>Number</td>
<td>Type</td>
<td>Timing</td>
<td>Percentage</td>
<td>Interval</td>
<td></td>
</tr>
<tr>
<td>-------------</td>
<td>------</td>
<td>--------</td>
<td>--------</td>
<td>------</td>
<td>--------</td>
<td>------------</td>
<td>----------</td>
<td></td>
</tr>
<tr>
<td>Chaushu et al. [26]</td>
<td>2009</td>
<td>28</td>
<td>72</td>
<td>Cancellous FDBA</td>
<td>simultaneous</td>
<td>94.4%</td>
<td>≤4mm</td>
<td>Mean of 27 months</td>
</tr>
<tr>
<td>Rizzo et al. [27]</td>
<td>2018</td>
<td>278</td>
<td>1024</td>
<td>Fresh frozen allogeneous bone blocks</td>
<td>simultaneous</td>
<td>97.7%/94.6%</td>
<td>nd</td>
<td>5 years</td>
</tr>
<tr>
<td>Rocha et al. [28]</td>
<td>2017</td>
<td>30</td>
<td>121</td>
<td>Fresh-frozen homologous block allograft</td>
<td>Delayed</td>
<td>98.3%</td>
<td>≤3mm</td>
<td>Between 12 and 124 months</td>
</tr>
<tr>
<td>Rizzo et al. [29]</td>
<td>2017</td>
<td>4</td>
<td>4</td>
<td>FMFHB allograft</td>
<td>simultaneous</td>
<td>No failure was recorded</td>
<td>≤3mm</td>
<td>3-6 years</td>
</tr>
<tr>
<td>Zvi Artzi et al. [30]</td>
<td>2002</td>
<td>10</td>
<td>36</td>
<td>B-SB</td>
<td>simultaneous</td>
<td>*</td>
<td>&lt;6mm</td>
<td>2 years</td>
</tr>
<tr>
<td>Sindel et al. [31]</td>
<td>2018</td>
<td>10</td>
<td>10</td>
<td>Autogenous bone ring from symphysis</td>
<td>simultaneous</td>
<td>90%</td>
<td>nd</td>
<td>24.3 months</td>
</tr>
<tr>
<td>Eurico et al. [32]</td>
<td>2013</td>
<td>28</td>
<td>90</td>
<td>Block bone allograft</td>
<td>Delayed</td>
<td>95.5%</td>
<td>2-4mm</td>
<td>18 months</td>
</tr>
<tr>
<td>Mangano et al. [33]</td>
<td>2013</td>
<td>5</td>
<td>19</td>
<td>HA blocks</td>
<td>Delayed</td>
<td>*</td>
<td>2-5mm</td>
<td>2 years</td>
</tr>
<tr>
<td>Isidori et al. [34]</td>
<td>2015</td>
<td>33</td>
<td>70</td>
<td>Autogenous bone cylinder or allograft</td>
<td>Delayed</td>
<td>97%</td>
<td>nd</td>
<td>10 years</td>
</tr>
</tbody>
</table>
FDBA=freeze-dried block allograft, FMFHB=fresh mineralized frozen homologous bone block, B-SB=Bovine mineral spongiosa block
HA=hydroxyapatite.

* all implants were regarded as integrated.
4.1 Retrospective cohort studies

Khoury et al. [23] performed a clinical study in which 216 sinus-lift procedures were completed from 1991 to 1995. In the study, 467 implants were positioned in 74 male patients’ and 142 female patients’ atrophic posterior maxillae. From the implant sites, the initial heights of the bone, using the orthopantomograms to measure, amounted to 1 to 5 mm. Bone block grafts were used as a support to the implants, which were obtained from the symphysis or retromolar region of the mandible. About 28 implants were unsuccessful. Other implants were considered osseointegrated successfully, on the basis of the clinical (as well as periodontal health) and radiographic prerequisites. In 51 patients visible perforations of the sinus membrane of less than 3 mm were observed and treated using fibrin adhesive. Maxillary sinus complications were not reported by any patients. The same study by Khoury et al. [23] discovered based on radiography and clinically, that the most suitable bone regeneration was noticed in patients who had a completely grafted surgically developed space alongside autogenous bone, which had a high rate of resorption-resistant type of cortical bone.

Sbordone et al. [24] compared the volumetric bone changes, using blocks of autogenous iliac bone or freeze-dried allogeneic bone (FDBA) from the hip, after sinus augmentation. Between each surgical procedure and the 2 sources, variables were compared at set times (pre augmentation-T0, before implant insertion-T2 and 1.5 year after transplantation- T3). The type of study was a non-randomized retrospective chart review which included 7 patients who had autogenous bone block grafted and 7 patients grafted with FDBA (1 procedure per patient). CT analysis was made using dentascan software. Changes between preoperative volume and postoperative volume were measured at four to six months (just before implant placement) and 1.5 year after transplantation. 14 implants were positioned in sinuses with grafted allogeneic bone, and 13 in autogenous grafts. For both of the sources annual and over all rates of bone change were calculated. The intraoperative volume of the grafts was identical-2.25 cc and from that point (T1) changes of volume were recorded at T2 and T3. The final volume of the autogenous group of grafts was 1.78 cc and 1.44 cc for allogeneic group. There were significant changes in volumes for both sources of transplanted grafts overtime found at T2: for the autogenous group the volume was 1.44 cc for time T2 (p = 0.016), whereas for the allogeneic group, the volume was 1.94 cc for time T2 (p = 0.015). Comparison of the rates of bone loss at 1.5-years post-operatively between sources was not statistically significant, Implant or graft failure was not reported.
In the same year (2014), Martuscelli et al. [25] published a retrospective cohort study which aimed at assessing the performance of implants that were placed after sinus augmentation using bone block autogenous graft, by comparing those implant to dental implant placed in ungrafted-bone. This study included 16 patients who, between 2000 and 2006, took part in a prosthetic rehabilitation supported by dental implants. Those patients were assigned into one of two groups: those with grafted maxillary sinus and those with ungrafted maxillary sinus (One implant per patient-16 implants were evaluated in total, 9 in the grafted group and 7 in the ungrafted). Changes over time in marginal bone level, as well as apical bone level (MBL and ABL) at 1, 3, and 5 years, were the primary outcome variables and tests of pair-wise comparison were made. No significant differences were seen among times and within ABLs between the two groups. Significant MBL loss was found over time, in both study groups. The bone around the apex of dental implants appeared to be stable. The behavior of the two groups with regard to loss of MBLs over time was very similar. From 37 implants which were placed beneath the sinus floor, 2 implants have failed from the ungrafted group. Thus the cumulative success rate for the ungrafted group was 87.5%, while the grafted group yielded a 100% success rate.

4.2 Case series

A study was carried out by Chaushu et al. [26] and was composed of 28 consecutive patients with age range of 25-65 years having the height of the posterior atrophic maxilla amounting to smaller and/or equal to about 4mm in a minimum of one implant site, while aiming at the valuation of the rate of survival regarding the dental implants positioned amid the augmentation and stabilized by the adoption of cancellous freeze-dried block allograft, there were about 72 different implants positioned out of (between 2 and 4 for each patient) which 68 major implants were considered clinically osseointegrated, producing a success rate of about 94.4%, while 4 particular implants, at the second phase, were considered to have failed. The mean follow-up was 27 months. Radiographs taken at the last follow-up revealed that the range of the vertical augmented bone inside of the sinus was between 11 mm and 14 mm (with mean at 12.3 mm). Moreover, the histologic assessment presented recently developed bone that has effective osteocytes unified with the residual grafted bone, which is based on vacant lacunae free of osteocytes. After the sinus lift operation (before implant placement) small membrane tears were noticed in six cases-they were left untreated because of the block graft, there was no record of complications in any of the sinuses.
Rizzo et al. [27] conducted a study in which a transcrestal sinus augmentation was performed in 278 surgeries, using fresh frozen allogenous bone blocks. A total of 1024 implants were placed during a period of 5 years. Implants were placed immediately after graft surgery and loading was done 5-8 mounts after grafting procedure-final restorations were delivered 3-4 mounts after loading. Radiographic and clinical evaluations were taken at baseline (after delivery of final restoration), 6, 12, 24 and 60 mounts after delivery of final restoration. The parameters that were measured were: implant mobility, presence/absence of inflammation, infection or pain, Implant failure (with specification of the reason) probing depth, gingival index, plaque index and implant survival and success rates. When the implant were uncovered fallowing 5-8 after grafting procedure and implant placement, 23 implants failed to integrate.3 grafts failed due to infection and in 9 partial graft sequestrum were noticed. After 60 months 969 implants were considered successful, 24 satisfactory survival, and 8 compromised survival. The cumulative survival and success rates, respectively, were 97.7% and 94.6%. Peri-implant probing values were within normal range (not deeper than 4 mm) and few bleeding on probing values were observed, the mean peri-implant score values were within normal range.

The next study for the analysis and follow-up of the implant placement in the posterior maxillary area, which was grafted with homologous bone, was completed by Rocha et al. [26] (2017). The process of the bone grafting was done with allogeneic bone that was freshly frozen in the corticomedullary blocks’ form. The maxillary sinuses were used to carry out about 41 grafts with homologous bone blocks in 30 patients who had a maximum of 3 mm alveolar ridge height, including 121 implants that were positioned in molar zones and premolar zones, roughly six months after the grafts were completed. The follow-up of the patients occurred between 12 and 124 months when the rehabilitation was completed. The success rate during the fallow up was 98.3%. With respect to the outcomes, the conclusion Rocha et al. (2017) drew was that the rate of success for the implants placed in the maxillary sinus regions occupied with homologous bone blocks was considered high.

Another case series was conducted by Rizzo et al. [27] to describe the Ebanist technique: an intended sinus lift procedure for critically resorbed bone crests (less or equal to 3mm), permitting simultaneous implant placement. A committed cylindrical trephine bur makes it possible to harvest a cylinder of bone from a fresh mineralized frozen homologous bone block as well as a trapdoor on the beneficiary site was all the while made in each of the 4 cases. Meanwhile, there is a detachment of the trapdoor cortical bone from the entire sinus membrane and then eliminated. The graft is used to house the dental implant prior to the grafting process as the moment the cylindrical block is
embedded in the recipient territory, is unable to restrict adequate resistance to the required torque for the placement of the implant. Each of the cases had an uneventful postoperative recovery: perfectly threatened soft tissues with no inflammation signs. The soft tissues continuously covered the dental implants and there was a 5 month follow-up plan, the moment there was a schedule put together to reveal the implants. Every implant required manual checking of the stability and there were no pathological signs or symptoms (peri-implant bleeding, peri-implant probing depth, and implant mobility) for individual implant. Moreover, there was a radiographic evaluation for cases #1 - #4 without any peri-implant bone loss and any pathological signs for 6,3,4,3 years for the #1 - #4 respectively when the implant placement is completed.

In 2002 Zvi Artzi et al. [28] published a study composed of 10 consecutive patients between 36 and 58 years (mean 49.2years) with posterior atrophic maxillary ridge height of less than 6 mm, who had Bovine mineral spongiosa block (B-SB) grafted into their sinuses and implants placed simultaneously. 12 months after implantation, healing of grafted area around implants was examined histologically and it was found that in all specimen hard tissue cores new bone formation was evident. Additionally, radiographic examination (Panoramic) revealed bone apposition around implant. All implant (36) were found to be clinically and radiographically integrated. All specimens had their peripheral/external and deep section slides stained with Mallory trichrome and Picrosirius red (PSR) and evaluated morphometrically with polarized light microscopy. At the peripheral side the average area of bone fraction was 34.2%, with a 1: 5.4 mean lamellar/woven bone ratio and at the deep side 53.0%, with 1: 2.5 mean ratios. There was a statistical significance in both parameters between the two sides.

In the study of Sindel et al. [29] Schneiderian membrane perforation occurred amid the lifting procedure, while the conventional methods were unable to get the perforation fixed. Consequently, 10 patients experienced an autogenous bone ring being positioned beneath the maxillary sinus and was bolted to the alveolar crest with a dental implant. A measurement of the marginal resorption close to the dental implants was done on panoramic radiographs, while the implants’ rate of survival over an average follow-up of 24.3 months amounted to 90%. There was failure of a case because of the alveolar crest resorption close to the implant due to infection; there was a removal of the adjacent ring and the implant at 1 month postoperative.
A new study in 2013 by Eurico et al. [30] dealt with the clinical outcomes (case series) of a number of patients getting block bone allograft utilized for sinus augmentation as well as delayed implant placement. Totally, there were 28 patients with an average age of 48.8 ± 10.1 years and 13 of which are males between 33 and 67 years of age were participants of this study. The patients chosen for this study were going through chronic alveolar ridge atrophy existing within the posterior maxilla and necessitated the procedures of bone augmentation, at the completion of implant placement, 6 months later. It took 18 months to follow the patients for the grafting, alongside scheduled visits per month and/or more constant visits if needed. Meanwhile, there was an evaluation of the survival rates of the bone blocks as well as their implants. About 90 implants and 42 blocks were all placed. One bone graft as well as five implants was unsuccessful; the rate of survival amounted to 95.5% and 97.2% for the implants and bone grafts, respectively. The unsuccessful state of the graft was based on the initiation of post-surgical infectious sinusitis; just as in the implants of a few patients indicated the lack of osteointegration when the healing session was completed. It is important to note that the unsuccessful implants were common among heavy smokers; the implants and blocks in the other patients were successful.

There was also a study by Mangano et al. [31] (2013) concerning the custom hydroxyapatite blocks (Biocoral, Milan Italy), with a preoperative cut into the right shape, on the basis of the 3D simulation, with the use of CAM/CAD technology. This particular HA blocks that were tailor-made were considered for the sinus augmentation. The bilateral sinus elevation was experienced by 5 patients alongside the tailored HA block and an alveolar ridge height of 2-5 mm was an inclusion criteria. After about six months, 19 implants placement of the maxillary sinus elevation was done. When the study ended, 2 years later of functional loading, the entire implants were in operation and there was neither prosthetic complication nor clinical complication. From the radiographic assessment, it was shown that a low inclination to marginal bone resorption exists as well as good stability of the peri-implant bone tissue.
Isidori et al. [32] (2015) carried out a prospective-study regarding a transcrestal sinus floor elevation alongside a particular bone block with the use of the press-fit method through the harvesting of a bone block alongside trephine burr so as to get a cylinder as well as eventually embed it within the antrum with the help of a crestal approach when the circular crestal window was made. The treatment was done on 33 patients, with 77 cylindrical bone blocks utilized for the bone grafting for 70 implants placement. About 27 of the total patients underwent the treatment for an allograft bone block while an autogenous bone cylinder was given to the six patients. 6.08 ± 2.87 mm was the result of the average bone augmentation, which ranged between 0 and 12.7 mm. The failure of one graft occurred prior to the implant placement. It took between 133 and 404 days to complete the follow-up when the implant insertion was done, alongside an average of 722 days. After the loading, the follow-up was between the range of 390 and 4,354 days, alongside 2173 days mean. The entire implants placement was at the scheduled location. There was only one unsuccessful implant. In 2002 the implant placement occurred and the failure occurred in 2007. After 10 years, the rate of survival was about 97%.
5. DISCUSSION

The aim of this systematic review was to test whether sinus augmentation performed with bone blocks is a predictable procedure with reliable outcomes. The outcomes measured were implant survival rate, marginal bone loss (MBL), bone regeneration and complications. High survival rates (more than 90%) were found, in this current review, for implants placed in block grafted sinuses regardless of the grafting material used. However, no long-term randomized controlled clinical trials comparing sinus augmentations with block bone grafts to other treatment modalities (particulated, graft free), were found. Two of the retrospective cohort studies included in this review [24, 25], compared the MBL of two different groups.

Sbordone et al. [24] have found that the differences in MBL between freeze-dried allogeneic bone block and autogenous bone block in a short term sinus augmentation procedure were not statistically significant. However, long term analysis and data are required to get definitive confirmation. Martuscelli et al. [25] reported that in terms of MBL both groups (autogenous block and ungrafted sinus) showed similar behavior. However in terms of implant survival rate, the autogenous grafted group had a 100% rate while the ungrafted group had a rate of 87%.

Depending on the height of the residual ridge, dental implant placement after sinus augmentation can be performed in a single or two surgical stages. In some studies a minimum of 4 to 5 mm of residual bone height is recommended for simultaneous implant placement after sinus lift procedure (one stage) [38], while in other studies a conclusion was reached that if sufficient primary stability can be achieved with the use of modified surgical methods, simultaneous implant placement in a residual bone of 1-2 mm can be performed [39].

In this current review several included studies [23, 26, 29, 30] performed sinus augmentation procedures with simultaneous implant placement in a residual ridge height of less than 4 mm, each using different type of bone block graft as well as a different modified surgical technique to achieve adequate primary stability and each high survival rates, which may help strengthen the mentioned conclusion above [37].

Out of all the case series studies in our review [26-34], five cases [26-29, 2, 34] used allograft blocks and demonstrated relatively predictable results. A certain histomorphometric split mouth study [38], compared autograft to fresh frozen allograft (both particulate grafts) in sinus augmentation using a total of 15 patients, found that histomorphometry, histology, and Implant survival of sinuses grafted with autogenous or fresh frozen bone were similar. These results, together with the findings of Sbordone et al [24], may suggest allograft as an alternative sinus
grafting material over autograft, since using autogenous grafts can be followed by increased harvested donor site morbidity and limitations in the quality and quantity of available bone, as mentioned in the introduction[10, 11, 18]. However the case series studies included in this current review each lack a control or comparison group except for one case study [32], thus in order to get a definitive confirmation regarding the usage of allogenic grafts over autografts in sinus augmentation procedures, more comparative and randomized controlled studies should be made.

The most common surgical complication of maxillary sinus augmentation is the perforation of the Schneiderian membrane, 7%-44% being the ranging incidence [41]. In accordance the most common complication found in the studies included in the current review was Schneiderian membrane perforation. While one included study [26] left the perforations untreated due to the fact that a block graft was used, another study [31] selected patients with extensive membrane perforations in which conventional methods have failed to repair them. None of the maxillary sinuses clinical and radiological findings have recorded any sinus pathology as well as no displacement of the graft into the sinus in both of the studies after sinus augmentations and follow up periods. This might be credited to the usage of block graft over particulate graft as suggested by Nkenke et al. [42] which recommended the use of block grafts in order to prevent the spread of grafting material into the sinus cavity.

6. CONCLUSION

To conclude, the findings of this study suggest that graft materials in block form have predictable outcomes in sinus augmentation procedures and that allograft blocks may be the best alternative over autograft blocks. However, long-term randomized controlled clinical trials comparing sinus augmentations with block bone grafts to other treatment modalities should be made in order to get a definitive confirmation on its efficacy and reliability.
7. REFERENCES


