Abstract

Objectives: The aim of this systematic review was to study the survival of dental implants placed in posterior maxilla with 4-8 mm residual bone height using one-stage lateral versus crestal sinus lifting approaches. Methods/Statistical Analysis: Three electronic databases and hand searching were performed up to February 2016 for studies, comparing lateral versus crestal sinus lifting approaches. The scientific terms: “Crestal approach”, “Lateral approach”, “Internal Sinus Lift”, “External Sinus Lift”, “Sinus Floor Augmentation” and “Dental Implants” were used. Initially, title and abstract screening was performed for the retrieved articles followed by a full-text evaluation. Meta-analysis for implant survival was performed using RevMan 5.1 software. Findings: Screening of 1321 papers resulted in four eligible articles. The included retrospective cohort studies showed high risk whereas in RCT, the risk of bias was low. Meta-analysis revealed no differences in implant survival [RR = 1.01 (95% CI: 0.98-1.05)] between both approaches. Application/Improvements: The less invasive crestal approach can successfully replace the one-stage lateral approach in patients with 4-8 mm residual bone height.

Keywords: Crestal Sinus Lift, Implant Survival, Lateral Sinus Lift, Meta-Analysis, Systematic Review

1. Introduction

Prosthetic rehabilitation of the edentulous posterior maxilla using endosteal implants is limited by sinus pneumatization and the quantity and quality of available bone.

For sinus lifting procedures, the lateral window technique was first introduced by Tatum, where a buccal window is prepared to gain access to elevate the sinus membrane creating a compartment for augmentation materials’ placement.

To minimize patient discomfort, an alternative technique using a crestal approach was advocated. Summers initially described this technique, which was further modified by Cosci & Luccioli. The sinus membrane is elevated through the alveolar crest using osteotomes and implants are directly inserted into the prepared sites.
The previous data lead to the formulation of a study question and a search strategy.

1.1 Search Strategy (Study) Question
Does the crestal sinus lifting approach with simultaneous implant placement have better implant survival rate, in patients with 4-8 mm residual bone height, compared with the one-stage lateral approach?

2. Materials and Methods

2.1 Protocol and Registration
The protocol of this systematic review was registered with the International Prospective Register of Systematic Reviews (PROSPERO) on 18th of July 2016 and was last-updated on 21st of August 2016 (registration number CRD42016043072).

2.2 Information Sources and Search Strategy
An electronic search was conducted on MEDLINE (through PubMed interface), the Cochrane Library, and EMBASE in the dental literature to select only published human clinical trials comparing crestal and lateral techniques (Figure 1).

2.3 Eligibility Criteria
The eligibility criteria were as follows:

- Patients provided their signed informed consent.
- Publications in English language.
- Population (P): Medically-free patients (at least 18 years old) with edentulous posterior maxilla, exhibiting Residual Bone Height (RBH) of 4-8 mm6,7 and undergoing sinus lifting procedure for dental implants’ placement.

Search terms used for PubMed-MEDLINE, Cochrane, and EMBASE. The search strategy was customized according to the database being searched.

The following strategy was used in the search:

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"Crestal approach" OR “Internal sinus lift” OR “osteocone-mediated sinus floor elevation” OR “Osteotome sinus floor elevation” OR “transcrestal sinus floor elevation” OR “Bone-added osteotome sinus floor elevation” OR “Bone-added osteotome technique” OR “BAOSFE” OR “TSFE” OR “OSFE” OR “OMSFE” OR “Closed approach” OR “Indirect sinus lift” OR “Closed sinus lift” OR “Sinus Floor Augmentation”[Mesh] OR “sinus membrane elevation” OR “sinus floor elevation” OR “maxillary sinus surgery” OR “maxillary antrum surgery” OR “sinus augmentation” OR “Augmentation, Sinus Floor” OR “Augmentations, Sinus Floor” OR “Floor Augmentation, Sinus” OR “Floor Augmentations, Sinus” OR “Sinus Floor Augmentations” OR “Maxillary Sinus Floor Augmentation” OR “Sinus Augmentation Therapy” OR “Augmentation Therapies, Sinus” OR “Augmentation Therapy, Sinus” OR “Sinus Augmentation Therapies” OR “Therapies, Sinus Augmentation” OR “Therapy, Sinus Augmentation” AND

“Sinus Floor Augmentation”[Mesh] OR “direct sinus lift” OR “Open sinus lift” OR “Lateral approach” OR “external sinus lift” OR “sinus membrane elevation” OR “sinus floor elevation” OR “maxillary sinus surgery” OR “maxillary antrum surgery” OR “sinus augmentation” OR “Augmentation, Sinus Floor” OR “Floor Augmentation, Sinus” OR “Augmentations, Sinus Floor” OR “Maxillary Sinus Floor Augmentation” OR “Sinus Augmentation Therapy” OR “Augmentation Therapies, Sinus” OR “Augmentation Therapy, Sinus” OR “Sinus Augmentation Therapies” OR “Therapies, Sinus Augmentation” OR “Therapy, Sinus Augmentation” AND

“Dental Implants”[Mesh] OR “dental implant” OR “dental implant, endosseous” OR “endosseous dental implant” OR “subperiosteal dental implant” OR “Implants, Dental” OR “Implant, Dental” OR “Dental Prostheses, Surgical” OR “Surgical Dental Prostheses” OR “Surgical Dental Prosthesis” OR “Prostheses, Surgical Dental” OR “Prosthesis, Surgical Dental” OR “Dental Prosthesis, Surgical”
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Figure 1. Search terms used for PubMed-MEDLINE, Cochrane and EMBASE.
• Intervention (I): Sinus floor augmentation using crestal approach.
• Comparison (C): Sinus floor augmentation using one-stage lateral approach.
• Outcome (O): Implant survival (absence of pain and discomfort, absence of clinically discernible mobility, absence of peri-implant radiolucency and infection) as primary outcome\(^8,9\), Implant stability (measured by Osstell or Periotest devices)\(^10\), implant failure (implant fracture or deep peri-implant pockets (>5 mm) with bleeding on probing)\(^8,9\), endosinus bone gain (measured as the sinus membrane level before and after the augmentation procedure)\(^11\), peri-implant pocket depth (measured as the peri-implant sulcus extending to the base of the pocket)\(^12\), change of grafted bone height (measured as graft resorption, using the grafted sinus membrane as a baseline)\(^13–15\), crestal bone loss around the implant (measured from the most coronal thread of the implant to the most apical bone-implant contact)\(^16\) as secondary outcomes.
• Timing (T): Minimum evaluation period of ≥12 months after sinus grafting and implants’ placement\(^8\).
• Study design (S): Randomized clinical trials, human clinical trials and retrospective cohort studies, comparing the survival of implants placed with crestal and one-stage lateral sinus lifting techniques.

2.4 Study Selection and Data Collection Process

Primary titles and abstracts screening was carried out by two independent reviewers. Secondary full-text screening was performed for potentially relevant studies. In cases of discrepancies, a consensus agreement was pursued between the two reviewers. Table 1 shows an overview of the included studies and data processed for extraction.

<table>
<thead>
<tr>
<th>Study</th>
<th>Study design / evaluation period</th>
<th>Participants</th>
<th>Treatment procedures and type of bone graft used</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Mean Residual bone height (RBH) (mm)</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Crestal</td>
</tr>
<tr>
<td>20</td>
<td>Retrospective-Cohort 12 months</td>
<td>182</td>
<td>40.2 ± 10.7</td>
</tr>
<tr>
<td>21</td>
<td>Retrospective – cohort 47.57±11.2</td>
<td>30</td>
<td>53.37±11.47</td>
</tr>
<tr>
<td>23</td>
<td>Retrospective - cohort parallel arm up to 9 years</td>
<td>42</td>
<td>?</td>
</tr>
<tr>
<td>22</td>
<td>RCT 5 years</td>
<td>40</td>
<td>Crestal:47.5</td>
</tr>
</tbody>
</table>

2.5 Assessment of Heterogeneity

Heterogeneity of the outcome parameters across studies was evaluated according to the following factors:

- Study design.
- Primary and secondary outcomes.
- Subjects characteristics.
- Follow-up periods.
- Grafting materials.
- Prosthetic supra-structure (splinted versus non-splinted).

2.6 Data Items

The type of intervention and control used, study design, duration of follow-up, patient characteristics (mean age, gender, population size, number of implants placed in each group, medical condition, periodontal condition, smoking status), pre-operative RBH, primary (implant survival) and secondary (implant failure, peri-implant pocket depth, endosinus bone gain, implant stability, crestal bone loss and change of grafted bone height) outcomes, were extracted.

2.7 Quality Assessment within and across the Included Studies

The Cochrane tool\textsuperscript{17} was used for RCTs quality assessment, whereas the Newcastle-Ottawa Scale (NOS)\textsuperscript{18} and RoBANS Tool\textsuperscript{19} were used for retrospective cohort studies. NOS categorized the studies into three groups according to the overall score: low (0-3 NOS stars), moderate (4-6) and high quality (7-9), whereas RoBANS and Cochrane Tools categorized the studies as high, low and unclear. Revman 5.1 software was used to compute graphic representations of potential bias within and across studies.

2.8 Synthesis of the Results and Summary Measures

Primary and secondary outcomes were analyzed. The risk ratio was calculated using RevMan 5.1 software. Heterogeneity was tested by chi-square test and I\textsuperscript{2}-statistic with chi-square test of p<0.1 representing significant statistical heterogeneity. To assess the magnitude of inconsistency across studies, I\textsuperscript{2}-statistic of 0–40 % was interpreted as mild heterogeneity and with >40% moderate to considerable heterogeneity was suggested.

3. Results

3.1 Study Selection

Four studies were included in this systematic review according to the inclusion criteria, among the 1321 studies that were screened through the title, abstract, and full-text (Figure 2).

3.2 Characteristics of Included Studies

3.2.1 Study Design, Research Groups and Evaluation Period

One RCT and three retrospective cohort studies were included. The evaluation period of the measured outcomes varied from 12 months\textsuperscript{20}, 47 months\textsuperscript{21}, 60 months\textsuperscript{22}, till 108 months\textsuperscript{23}. Allocation concealment and masking were reported only in one study\textsuperscript{22}.

3.2.2 Subject Characteristics and Smoking Habits

The following criteria were considered in the included studies when recruiting subjects; medically free patients with single or multiple missing teeth in the posterior maxillary region. Only two studies defined the good periodontal condition as an inclusion criterion\textsuperscript{20,22}. A study\textsuperscript{22} categorized the included patients into three categories: Non-smokers, light smokers and heavy smokers. Only subjects who smoke less than ten cigarettes per day were included in one study\textsuperscript{23}. One study\textsuperscript{21} did not evaluate the smoking status of the included patients. One study\textsuperscript{20} defined chronic smoking as an exclusion criterion. The impact of smoking on the outcome parameters was analyzed by only one study\textsuperscript{22} that showed a higher number of smokers in the crestal approach compared to the lateral approach group.

3.2.3 Sinus Lifting Technique, Settings and Procedures

With regards to the crestal approach, three studies used the Osteotome-Sinus-Floor-Elevation (OSFE)\textsuperscript{20,21,23}. One study\textsuperscript{23} used Cosci technique where osteotomies were prepared using a trephine drill, 1 mm short of the sinus floor and then an atraumatic sinus lifting drill was used. As a comparison, classic lateral window sinus lift procedure was used by all the included studies.

3.2.4 Assessment of Heterogeneity

Heterogeneity was noted in the four studies in regards to study design, evaluation period, study population, number, gender, age of participants and types of bone grafts.
Figure 2. PRISMA flow diagram showing search and selection results. Details of excluded studies can be found in Online Supplement 1.
3.3. Quality Assessment within the Included Studies

The included RCT\textsuperscript{22} showed a low risk of bias according to Cochrane Tool (Online Supplement 2). The included retrospective cohort studies\textsuperscript{20,21,23} showed high risk of bias according to the NOS (Online Supplement 3a) and varied from high to unclear according to RoBANS Tool (Online Supplement 3b). Figure 4 shows a graphic representation of potential bias within the individual studies.

3.4 Results of Individual Studies

3.4.1 Implant Survival and Failure

Implant survival and failure was measured by all of the eligible studies (Online supplement 5). Implant failures were reported by Balaji\textsuperscript{20} in both groups (lateral 0/89, crestal 0/108), Kim\textsuperscript{21} reported four failures (4/51) in the lateral versus none (0/25) in the crestal group. One study\textsuperscript{23} experienced three (3/36) in the lateral versus five (5/56) failures in the crestal group, whereas Cannizzaro\textsuperscript{22} reported five (5/44) in the lateral versus one (1/38) failure in the crestal group. Consequently, a meta-analysis for implant survival could be performed. The meta-analysis could be performed for three of the four included studies with regards to the implant survival outcome.

3.4.2 Implant Stability and Crestal Bone Loss

In the current review, two studies measured the crestal bone loss\textsuperscript{22,23}, whereas only one study measured the implant stability using osstell and periotest\textsuperscript{22} (Online supplement 5, 6).

3.4.3 Peri-implant Pocket Depth, Endosinus Bone Gain and Change of Grafted Bone Height

Peri-implant pocket depth was not reported in any of the included studies. Endosinus bone gain was measured in one study\textsuperscript{20}, whereas the change of grafted bone height was reported by another study\textsuperscript{21} (Online supplement 4).

3.4.4 Complications

One study\textsuperscript{22} reported overall eight complications in seven patients in the lateral versus four complications in four patients in the crestal group, but no significant differences were reported between both groups regarding complications. Five implant failures were reported in the lateral group versus one in the crestal group. Overall 20 complications were reported in one study\textsuperscript{21} where four implant failures occurred in the lateral group versus none in the crestal group.

Sinus membrane perforations were reported in two studies\textsuperscript{21,22}. One study\textsuperscript{21} reported overall 12 sinus membrane perforations in 40 procedures. Another study\textsuperscript{22} reported two membrane perforations in the lateral group versus none in the crestal group. Perforations were sealed with a collagen membrane and the subjects continued the study.

3.5 Meta-Analysis (Synthesis of Results)

The available data were amenable to meta-analysis with regards to implant survival. Other outcomes were not combinable, thus no meta-analysis was performed for the peri-implant pocket depth, endosinus bone gain, change of grafted bone height, crestal bone loss and implant stability.

3.5.1 Implant Survival

Employing a fixed-effect model, implant survival outcome values showed no significant difference between crestal and one-stage lateral approaches ($p = 0.52$, risk ratio $RR = 1.01$, 95% Confidence Interval [CI] = 0.98-1.05). The unit of analysis was at the implant site level, as implant survival was the only outcome amenable to meta-analysis. The cochrans-Mantel-Haenszel statistical method\textsuperscript{24} has been used. Heterogeneity was assessed by chi-square test and $I^2$-statistic. Overall test statistics ($Z$) and level of significance ($p$) are presented. The Revman 5.1 software was used for calculations and generation of the forest plot (Figure 3).

3.6 Quality Assessment across the Included Studies

Testing for publication bias could not be used due to low statistical power as the meta-analysis included less than ten studies\textsuperscript{25}. Figure 5 shows a graphic representation of potential bias across the included retrospective cohort studies. Selective outcome reporting, blinding of the outcome assessments and selection of participants showed a high risk (100%), confounding variables unclear (30%) and low risk (0%) for measurement of exposure and incomplete outcome data. However, the included RCT showed low risk in all parameters.
4. Discussion

This systematic review analyzed the current evidence on the effect of crestal versus one-stage lateral approach for sinus lifting on the survival of simultaneously placed implants.

In the current review, strict inclusion criteria were implemented to select relevant studies. One prospective RCT, directly comparing the crestal versus the one-stage lateral approach, was identified. Three eligible studies were retrospective cohorts.

The NOS and the Cochrane tool were used for quality assessment. The retrospective cohort studies showed a high risk of bias by the NOS scale, whilst the Cochrane tool showed a low risk for the included RCT. The retrospective cohorts were additionally assessed using the RoBANS Tool which resulted in almost the same risk of bias when compared to the NOS except for one study that was rated as unclear due to variation in categorization of the overall score.

Meta-analyses confined to RCTs are preferred to those of observational studies, as the latter may produce a biased estimate, stemming from selection bias and confounders, that the included studies was not able to adjust for completely. However, in many situations, only data from observational studies are available; yet, they provide a guide to quantify the current evidence and revealing areas warranting further research. A consensus report developed a guide for reporting meta-analyses of observational studies, which was followed where appropriate.

Although the present meta-analysis was based on the results of a limited number of retrospective cohort studies and was performed for only one parameter, namely implant survival, it represents the most important endpoint parameter of implant-based dental rehabilitation. Other outcomes were not combinable, thus no meta-analysis was performed for them. There remains a possibility...
Implant Survival in One-Stage Lateral versus Crestal Sinus Lift Procedures - A Systematic Review and Meta-Analysis

for language and publication bias as only articles published in English were included, and unpublished work was not sought. Furthermore, confounding factors in the meta-analysis, including smoking, bone quality and quantity in terms of ridge width and height and poor initial primary stability, were not accounted for.

RBH remains the principal factor affecting primary implant stability and plays a significant role in implants’ survival. RBH 4-8 mm was used as an inclusion criterion based on the 1996 consensus conference. A recent systematic review concluded that RBH <4 mm influences implant survival, hence RBH 4-8 mm seemed appropriate as an inclusion criterion for one-stage approach regardless of crestal or lateral. Reduced subsinus bone height can occur as a result of vertical ridge resorption, sinus pneumatization or both. Regardless of the direction of resorption, the current review investigated the predefined outcomes with both sinus augmentation approaches.

The included studies evaluated 447 implants in 294 participants. Heterogeneity was noted with regards to study design (RCT and retrospective cohorts) and evaluation periods (1-9 years). The mean age of included subjects ranged from 40 to 64 years old. The classic lateral window sinus lift procedure was used by all included studies, whereas almost the same OSFE technique was used in three studies. One study applied Cosci technique, where implant osteotomies were prepared with a trephine drill, then a sinus lifting drill was used. Consequently, a mild heterogeneity regarding techniques was noted. Furthermore, heterogeneity for grafting materials used was noted; employing xenograft or autograft and autograft. In one study, bone grafts were divided into two groups; one containing autograft mixed with allograft or xenograft and the other group containing a mix of allograft and xenograft. The included RCT used autograft in the crestal group and a mixture of xenograft and autograft in the lateral group. These different grafting materials vary in their osteogenic potential and their resorption time. Regarding prosthetic supra-structure, in one study, 17 implants were non-splinted, whereas 75 implants were splinted to other implants. Two failures were reported in the splinted group versus six in the non-splinted group. The study reported that survival of implants placed in posterior maxillae was not affected by the prosthesis type. Three studies did not report on splinting of the implants, introducing further heterogeneity. However, statistical heterogeneity regarding implant survival was found to be mild ($I^2 = 30\%$).

Although previously published systematic reviews referred to the effect of both approaches on implant survival/failure, however, the present review included new studies. Indeed, the present review further included only patients undergoing crestal and one-stage lateral approaches, as both share almost the same indication, while the previous ones included participants undergoing both approaches, without considering both subgroups (one/two-stage), which seems inappropriate because of different indications. One review did not include any RCTs or controlled clinical trials, whereas another included one RCT. The current review included three comparative studies without predetermining RBH as an inclusion criterion, with a literature search conducted up to January 2013 and no reporting on the quality assessment process or tools used for the included articles.

The current meta-analysis showed no significant difference between both approaches regarding the survival of simultaneously placed implants, thus explicitly questioning the value of using one technique over the other. Given the additional surgical trauma, chair-side time, post-operative discomfort, required operator experience and skills; the authors, however, suggest the use of the crestal over the one-stage lateral approach in cases where both are indicated and good primary stability is achievable.

This systematic review shows that there is no high-quality evidence that compares both approaches and represents the best available evidence, in the presence of only one randomized controlled trial. Consequently, this review demonstrates a knowledge gap in high-quality evidence, comparing both approaches that requires further high-quality prospective RCTs to confirm this systematic review’s findings.

5. Conclusion

In this systematic review, the Meta-analysis revealed no differences in implant survival between crestal and one-stage lateral approaches. Consequently, the less invasive crestal approach can successfully replace the one-stage lateral approach in patients with 4-8 mm residual bone height.

6. Conflict of Interest and Source of Funding

The study was self-funded by the authors.
All authors report no conflict of interest. This study was conducted as a part of the obligation of the first author to fulfill the requirements of the Cairo University Ph.D. program.

7. References


