Evaluate the long-term hard tissue stability and relapse factors following surgical–orthodontic treatment: A systematic review and meta-analysis

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Abstract---Background and aim: the present study was conducted with the aim of evaluating the long-term hard tissue stability and relapse factors following surgical-orthodontic treatment. Method: Databases of PubMed, Scopus, Web of Science, EBSCO, ISI Web of knowledge and Embase were searched for systematic literature until July 2022. 95% confidence interval for mean differences with fixed effect model and Inverse-variance method were calculated. To deal with potential heterogeneity, random effects were used and $I^2$ showed heterogeneity. Meta-analysis was performed using Stata/MP v.17 software. Result: In the initial review, duplicate studies were eliminated and abstracts of 201 studies were reviewed, the full text of 38 studies was reviewed by two authors, finally, ten studies were selected. Overbite changes, Upper incisor changes and Lower incisor changes after combined orthodontic and orthognathic surgical treatment in class II and III patients during long-term follow-up was 1.80 (MD 95% CI; 1.43 and 2.17), -0.51 (MD 95% CI; -1.08 and 0.05) and 0.27 (MD 95% CI; 1.03 and 1.58), respectively. Conclusion: Based on the findings of the present study, in patients with skeletal class II
and III, the results of long-term dental changes after combined orthodontic and orthognathic surgery are very diverse.

**Keywords**—surgical-orthodontic treatment, orthodontic, orthognathic surgery.

**Introduction**

To correct severe dental and skeletal abnormalities and achieve a satisfactory result and facial balance, it is necessary to use combined orthodontic treatment and orthognathic surgery. Two mandibular bilateral sagittal split osteotomy (BSSO) and maxillary Le Fort I osteotomy are used. The important goal of combined orthodontic treatment and orthognathic surgery is to achieve tooth stability, whether it can be long-term or short-term stability. Evidence shows that recovery after surgery leads to short-term stability, which is also referred to as physiological adaptation. Long-term stability is affected by factors such as patient-related factors (neuromuscular adaptation, neuromuscular adaptation, age, masticatory function, pressure due to the adaptive position of the tongue, abnormal behavior of the oral muscle), orthodontic treatment (pre- and post-operative to create stable occlusion), surgical factors (surgical experience, condylar repositioning in the glenoid fossa and fixation material) depend.

Before the surgery, orthodontic treatment is used due to arch coordination to maximize the optimal surgical position of the jaw and align the teeth, and after the surgery, it is done to improve occlusion and retention. Evidence shows that dental changes after surgery generally occur two to six years, and studies with a long follow-up period should be performed. In the present study, an attempt has been made to examine dental changes in studies with a follow-up period of 5 years or more, so that with the consensus of the findings of the studies, stronger evidence can be reported regarding long-term dental changes after surgery. Therefore, the present study was conducted with the aim of evaluating the long-term hard tissue stability and relapse factors following surgical-orthodontic treatment.

**Method**

**Search strategy**

Present study is a systematic review and meta-analysis based on PRISMA guidelines, all articles published in international databases such as PubMed, Scopus, Web of Science, EBSCO, ISI Web of knowledge and Embase until July 2022 included. Google Scholar search engine was used.

*The following keywords were used to search:*


Key considerations PRISMA was the basis of the present study(11) and PICO strategy to answer the research questions showed in Table1.

Selection criteria

Inclusion criteria: criteria: Clinical controlled trials, randomized controlled trials, and cohort studies, case series, Sample size above 10 patients, combined orthodontic and orthognathic surgical, long term follow-up period (>5 years), English language. case reports, reviews, animal studies and Letter to the editor were excluded from the study.

Table1. PICO strategy

<table>
<thead>
<tr>
<th>PICO strategy</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>P</td>
<td>Population: Patients undergoing combined orthodontic and orthognathic surgical treatment</td>
</tr>
<tr>
<td>I</td>
<td>Intervention: orthodontic and orthognathic surgical treatment</td>
</tr>
<tr>
<td>C</td>
<td>Comparison: different skeletal classes, type of osteotomy and surgical procedure.</td>
</tr>
<tr>
<td>O</td>
<td>Outcome: Occlusal parameters, clinical examination, Imaging data</td>
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</tbody>
</table>

Study selection, Data Extraction and method of analysis

Studies data were reported by first author name, years, study design, number of Participants, mean of age, Follow-up period.

ROBINS-I tool (12) used to assessed quality of the Non-randomized control clinical trial studies, This scale measures seven different domains. In the analysis, any studies with ROBINS-I tool scores of 1-3, 4-6 and 7-9 were defined as high, medium and low risk of bias, respectively.

randomized control clinical trial studies was evaluated using the Cochrane Collaboration’s tool(13). The scores of this tool are between 0 and 6, and higher score showed higher quality of study; the scoring of each item is 1 for low risk and 0 for high and unclear risk.

Stata/MP. V16 software was used for data analysis. Mean differences was done with 95% confidence interval (CI), fixed effect modal and inverse-variance method. The level of heterogeneity was evaluated using the I^2 index test (I^2 < 50% = low levels, 50 < I^2 < 75% = moderate and I^2 > 75% = high levels).

Result

The review of the existing literature using the studied keywords, 214 studies were found. In the initial review, duplicate studies were eliminated and abstracts of 201 studies were reviewed. At this stage, 163 studies did not meet the inclusion criteria, so they were excluded, and in the second stage, the full text of 38 studies was reviewed by two authors. At this stage, 28 studies were excluded from the study due to incomplete data, inconsistency of results in a study, poor studies,
lack of access to full text, inconsistent data with the purpose of the study. Finally, ten studies were selected (Figure 1).

Figure 1. PRISMA flowcharts

**Characteristics**

Two RCT studies and eight Retrospective studies have been included in present article. A total 920 patients were examined. The range of follow-up period was between 5 to 15 years.
Table 2. Summary of demographic and clinical data of studies selected

<table>
<thead>
<tr>
<th>Study, Years</th>
<th>Study design</th>
<th>Number of Patients</th>
<th>Malocclusion class</th>
<th>Osteotomy type</th>
<th>Follow-up (years)</th>
<th>Method of analysis</th>
<th>Bias assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brandtner et al., 2015 (14)</td>
<td>R</td>
<td>38</td>
<td>35</td>
<td>NR</td>
<td>II</td>
<td>AD</td>
<td>AD</td>
</tr>
<tr>
<td>Bailey et al., 2008 (15)</td>
<td>R</td>
<td>60</td>
<td>60</td>
<td>24</td>
<td>III</td>
<td>AD</td>
<td>AD</td>
</tr>
<tr>
<td>Josa et al., 2008 (16)</td>
<td>R</td>
<td>6</td>
<td>6</td>
<td>27</td>
<td>III</td>
<td>ND</td>
<td>AD</td>
</tr>
<tr>
<td>Ding et al., 2007 (17)</td>
<td>R</td>
<td>8</td>
<td>8</td>
<td>24</td>
<td>I, II &amp; III (open bite)</td>
<td>AD</td>
<td>AD</td>
</tr>
<tr>
<td>Eggensperger et al., 2007 (18)</td>
<td>R</td>
<td>14</td>
<td>14</td>
<td>36</td>
<td>II &amp; III</td>
<td>ND</td>
<td>AD</td>
</tr>
<tr>
<td>Bailey et al., 2007 (19)</td>
<td>R</td>
<td>57</td>
<td>24</td>
<td>III</td>
<td>AD</td>
<td>AD</td>
<td>AD</td>
</tr>
<tr>
<td>Proffit et al., 2004 (19)</td>
<td>R</td>
<td>507</td>
<td>NR</td>
<td>II &amp; III</td>
<td>AD</td>
<td>AD</td>
<td>AD</td>
</tr>
<tr>
<td>Eggensperger et al., 2006 (20)</td>
<td>R</td>
<td>3</td>
<td>3</td>
<td>28</td>
<td>III</td>
<td>ND</td>
<td>AD</td>
</tr>
<tr>
<td>Dolcos et al., 2003 (21)</td>
<td>RCT</td>
<td>57</td>
<td>31</td>
<td>II</td>
<td>ND</td>
<td>AD</td>
<td>AD</td>
</tr>
<tr>
<td>Dolcos et al., 2002 (22)</td>
<td>RCT</td>
<td>47</td>
<td>31</td>
<td>II</td>
<td>ND</td>
<td>AD</td>
<td>AD</td>
</tr>
</tbody>
</table>

R: Retrospective; RCT: randomized controlled trial; NR: not reported; AD: available data; ND: data not available; LC: lateral cephalometry

Overjet changes

Overjet changes after combined orthodontic and orthognathic surgical treatment in class II and III patients during long-term follow-up was -0.27 (MD 95% CI; -1.18 and 0.64) (I²<0%; P=0.42; low heterogeneity). Test of group differences showed there was no significant differences between groups (p=0.13). according to figure 2, changes < 2 mm are not clinically relevant. For skeletal class II patients, an increase in Overjet was seen in the studies of Proffit et al., 2004 and Brandtner et al., 2015.
Figure 2. forest plot showed Overjet changes after combined orthodontic and orthognathic surgical treatment

**Overbite changes**

Overbite changes after combined orthodontic and orthognathic surgical treatment in class II and III patients during long-term follow-up was 1.80 (MD 95% CI; 1.43 and 2.17) (I²=39.99%; P=0.12; low heterogeneity). Test of group differences showed there was significant differences between groups (p=0.02). according to figure 3, changes < 2 mm are not clinically relevant and changes > 2 mm during follow-up are considered clinically relevant. Two studies showed a clinically significant increase in Overbite for skeletal class II patients at long-term follow-up(1, 2).

**Upper incisor (U1) changes**

U1 changes after combined orthodontic and orthognathic surgical treatment in class II and III patients during long-term follow-up was -0.51 (MD 95% CI; -1.08 and 0.05) (I²=0%; P=0.98; low heterogeneity). Test of group differences showed there was no significant differences between groups (p=0.55). The vertical and horizontal positional changes of the maxillary incisors are shown figure 4.

**Lower incisor (L1) changes**

U1 changes after combined orthodontic and orthognathic surgical treatment in class II and III patients during long-term follow-up was 0.27 (MD 95% CI; 1.03 and 1.58) (I²=0%; P=0.98; low heterogeneity). Test of group differences showed there was no significant differences between groups (p=0.86). The vertical and horizontal positional changes of the mandibular incisors are shown figure 5.
Figure 3. Forest plot showed Overbite changes after combined orthodontic and orthognathic surgical treatment in class II and III patients
Figure 4. Forest plot showed U1 changes after combined orthodontic and orthognathic surgical treatment in class II and III patients.
Figure 5. Forest plot showed L1 changes after combined orthodontic and orthognathic surgical treatment in class II and III patients

Dentolabial changes of Sagittal

Dentolabial changes of Sagittal after combined orthodontic and orthognathic surgical treatment in class II and III patients during long-term follow-up was -0.49 (MD 95% CI; -1.63 and 0.65) (I²=0%; P=0.99; low heterogeneity). Test of group differences showed there was no significant differences between groups (p=0.98) (Figure 6).

Dentolabial changes of Vertical

Dentolabial changes of Vertical after combined orthodontic and orthognathic surgical treatment in class II and III patients during long-term follow-up was 0.44 (MD 95% CI; -1.07 and 1.05) (I²=0%; P=0.88; low heterogeneity). Test of group differences showed there was no significant differences between groups (p=0.72) (Figure 7).
Figure 6. Forest plot showed Dentolabial changes of Sagittal after combined orthodontic and orthognathic surgical treatment in class II and III patients.
Discussion

The present study was conducted with the aim of evaluating the long-term hard tissue stability and relapse factors following combined orthodontic and orthognathic surgery. In the present study, most of the selected studies were retrospective and the period of investigation was 5 to 15 years. Dental or skeletal recurrence greater than or equal to 2 mm is clinically important and should be considered in the postoperative follow-up (19). Therefore, the use of combined orthodontic-orthognathic treatment is very important to achieve a long-term stability and can correct the inconsistencies of the dental skeleton in the long term. According to the results of the present study, relapse after treatment was very extensive; Meta-analysis showed that Overjet tends to increase and decrease over time in patients with skeletal class II and III, respectively. A retrospective study suggested that the use of bimaxillary surgery can reduce the length of the lower jaw in skeletal class II patients (19); It should be noted that in the long-term follow-up, the patients showed a slight increase in Overjet. Another study reported better sagittal stability based on correct transverse width and cuspid angulation in class II patients undergoing two-piece Le Fort and BSSO advancement (14). Based on the results of studies, vertical recurrence can depend on several factors, including, unfavorable growth pattern, size or condition of the tongue, condyle analysis, oral and facial muscles, and unfavorable growth pattern (22). Meta-analysis showed that overbite remained stable after long-term follow-up due to more compensatory growth of maxillary and mandibular incisors.
Studies reported that dentolabial outcomes are directly related to anterior teeth and lip position(1, 2, 18). After combined orthodontic and orthognathic surgery, the changes in the appearance of the maxillary and mandibular incisors depend on the downward movement and thinning of the lips. Based on the available evidence, aging has a significant direct relationship with these changes(1). The existing studies related to the purpose of the present study had a small sample size and most of them were retrospective and the quality of the studies was low. No study was found that compared short-term results with long-term results, nor was the use of 3D imaging used to examine outcomes. One of the very important limitations of the current study was the obvious difference in the cognitive methodology of the studies, which has caused high heterogeneity between the findings of the studies; Therefore, the interpretation of the findings of the present study should be done with caution. Also, examining studies with a long follow-up period makes dental changes to be examined more precisely, and this is one of the advantages of the present study. It is suggested that future studies with a larger sample size, comparison of immediate and long-term results after the operation and use of CBCT or CT imaging methods be performed. Also, it is better that the study design and the evaluation method of the studies are similar so that the interpretation of the results can be done more accurately and also the evaluation of the aesthetic findings, root analysis and the level of patient satisfaction are also considered.

Conclusion

The findings of the present study show that in patients with skeletal class II and III, the results of long-term dental changes after combined orthodontic and orthognathic surgery are very diverse; Therefore, designing a good procedure and using CBCT or CT imaging methods can provide valuable results. Considering the heterogeneity and high bias of the studies, the interpretation of the findings of the present study should be done with caution.

References