Long-term skeletal stability after maxillary advancement with distraction osteogenesis in cleft lip and palate patients

A systematic review

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ABSTRACT

Objective: To systematically review the long-term skeletal stability after maxillary advancement with distraction osteogenesis (DO) in cleft lip and palate (CLP) patients.

Materials and Methods: Electronic databases, grey literature, and reference list searches were conducted. The inclusion criteria were stability of maxillary advancement with distraction osteogenesis assessed at the posttreatment follow-up $\geq$ 1 year in CLP patients. Full articles were retrieved from abstracts or titles that appear to meet the inclusion criteria or lacked sufficient detail for immediate exclusion. Once full articles were collected, they were again reviewed considering more detailed inclusion criteria for a final selection decision. A methodologic quality assessment tool was utilized.

Results: Thirty abstracts/titles met the initial search criteria, and 13 articles were finally selected. Overall, methodologic quality scores were high in only one randomized clinical trial. After maxillary advancement with DO in CLP patients, the long-term horizontal relapse in A-point was less than 15% in eight studies and between 20% and 25% in four studies. The study that was judged as a high-quality study reported 8.2% horizontal relapse in A-point. The relapse rate was higher in DO with external distracter device than DO with internal distracter device.


KEY WORDS: Stability; Distraction osteogenesis; Cleft lip and palate; Systematic review

INTRODUCTION

Patients with cleft lip and palate (CLP) usually develop a significant maxillary hypoplasia that requires orthognathic surgery procedures. These surgeries are indicated in approximately 25% to 40% of CLP patients and aim to achieve functional and esthetic results by advancing the maxilla.\textsuperscript{1,2}

The traditional and standard surgical procedure for correcting associated maxillary retrusion is the conventional Le Fort I osteotomy.\textsuperscript{3} Over the last 15 years, distraction osteogenesis (DO) has become an apparently effective and reliable alternative technique in the management of maxillary hypoplasia in CLP patients.\textsuperscript{4,5}

Management of maxillary hypoplasia in CLP patients has been a challenge for the reconstructive team as the surgical approach may not be stable enough.\textsuperscript{2} One of the features of DO is that it allows for a progressive bone regeneration accompanied by more gradual soft tissue adaptation, which may contribute to less relapse.\textsuperscript{2} This is crucial, especially in the management of CLP patients, because of the increased soft tissue tensions due to scar contracture.\textsuperscript{8}

It is important, therefore, to assess not only the immediate post intervention effects but also the long-term effects and relapse. A previous literature review
of cleft maxillary osteotomy and DO found that both
techniques, conventional Le Fort I osteotomy and
DO, can achieve a pronounced improvement with no
differences in velopharyngeal function, speech, and
short-term stability. This review assessed post
intervention effects, but did not consider the long-
term stability. Additionally, it was published in 2006
and, thus, new data may have become available that
could challenge its conclusions. The objectives of
this article are, therefore, to systematically review
the long-term skeletal stability after maxillary ad-
vancement with DO in CLP patients and to update
previous evidence-based recommendations with new
findings.

MATERIALS AND METHODS

The research design of this article was a systematic
review of the literature. Reporting of this systematic
review was based on the Preferred Reporting Items for
Systematic Reviews and Meta-Analyses (PRISMA)
statement for reporting systematic reviews of studies
that evaluate health care interventions. No ethics
approval was required for this research as there was
no human or animal intervention.

Data Sources and Searches

Electronic searches up to December 9, 2011 were
conducted using the following electronic bibliographic
databases: PubMed (1966 to December 2011, week 2);
MEDLINE (1980 to 2011, week 52); Embase (1980 to
2011, week 52); ISI Web of Science (1965 to December
9, 2011); EBM (Evidence-Based Medicine) Reviews:
Cochrane Central Register of Controlled Trials (CCTR)
(1991 to 4th quarter of 2011); all EBM Reviews,
comprising the Cochrane Database of Systematic
Reviews (CDSR), ACP (American College of Physicians)
Journal Club, Database of Abstracts of Reviews of
Effects (DARE) (1991 to 4th quarter of 2011); and
HealthSTAR (1966 to November 2011). Key words used
in the search were: “cleft,” “distraction osteogenesis,”
“relapse,” “stability,” “recurrence,” and “follow-up stud-
ies.” Table 1 provides details on the specific search terms
and combinations used in each individual database.

The electronic searches were developed with the
assistance of a librarian specializing in health science
databases. The literature search also involved search-
es through the bibliographies of relevant publications.
No restrictions were applied regarding publication year
or language. The references resulting from the
searches were entered in EndNote X4, and within this
program duplicates were electronically removed.
When additional information was needed, efforts were
made to contact the authors.

Study Selection

Appropriate studies to be included fulfilled the
following predefined inclusion criteria:

- **Population:** Cleft lip and/or palate patients.
- **Intervention:** Surgical therapy of maxillary hypoplasia
  with distraction osteogenesis.
- **Outcome:** Stability of the outcome assessed at least
  12 months post treatment.
- **Study design:** Randomized and nonrandomized
  controlled clinical trials, clinical trials, case series
  studies, and prospective and retrospective studies
  were included. Case reports with ≤ five subjects,
  animal studies, systematic reviews, meta-analyses,
  and editorials articles were excluded.

Two researchers independently reviewed the list of
titles and abstracts for inclusion. Once potentially
adequate abstracts were selected, full articles were
retrieved in a second final selection process. If the
abstract was judged to contain insufficient information
for a decision of inclusion or exclusion, the full article
was obtained and reviewed before a final decision was
made. Any discrepancies in inclusion of articles
between researchers were addressed through discus-
sion until consensus was reached.

Data Extraction and Methodologic
Quality Assessment

To perform an analysis of the included studies, data
were collected for each selected study on the following
items: study design, age, sample size, type of cleft,
surgical procedure, latency period, device, rate of
distraction, consolidation period, follow-up period, and
mean movement and mean relapse in the horizontal
and vertical dimensions (Table 2). In addition, to
evaluate the methodologic quality of each study, a
methodologic quality assessment was performed by
analyzing the study design, the study measurements,
and the statistical analysis for each selected study
(Table 3). The scoring process was a modified version
of a previously developed checklist used in a system-
atic review published by one of the study authors. Each
study was scored by the same two investigators,
and discrepancies were resolved by discussion until
consensus was reached. The maximum quality score
possible was 19. A meta-analysis was planned if the
quality of the information retrieved warranted a
meaningful statistical combination.

RESULTS

The search strategy returned 310 potential articles
for inclusion. The search results from different elec-
tronic databases are listed in Table 1.
Of the 310 abstracts, 30 full articles were retrieved for more detailed evaluation. Of the 30 full articles retrieved, only 13 studies fulfilled the final selection criteria and were included in the study. No articles were found during grey literature searches or reference list searches. A flow diagram of the literature search is given in Figure 1.

Of the 30 full articles initially selected, seven were excluded because there was no long-term follow-up, seven were excluded because of an incomplete report of data, one because Class III patients were included, and one because it was a meta-analysis. We attempted to contact the authors of articles with incomplete report of data but no responses were obtained. Table 5 provides the list of the 17 excluded articles and the reasons for their exclusion.

Ultimately, only 13 articles that fulfilled all of the inclusion criteria remained. Table 2 provides a study summary of the study design, age, sample size, type of cleft, surgical procedure, latency period, device, rate of distraction, consolidation period, follow-up period, mean movement, and mean relapse in the horizontal and vertical dimensions. Meta-analysis was not possible due to heterogeneity of outcome measures. Methodologic quality assessment of the finally selected articles resulted in scores ranging from 26% to 87% of the possible total maximum. Methodologic scores are summarized in Table 4.

### DISCUSSION

Maxillary surgical advancement is the most common surgical technique for correcting maxillary hypoplasia in CLP patients. Alternatively, distraction osteogenesis is another commonly used technique that may have less relapse. In this systematic review, all of the clinical trials and case series that examined the long-term skeletal stability of DO maxillary advancement were included. For the purposes of this review, postsurgical posterior and superior changes of the maxilla were considered as relapse since the treatment direction is usually an anterior and inferior movement of the maxilla.

The study designs of the 13 articles were as follows: one prospective randomized clinical trial, one prospective clinical trial, one retrospective clinical trial, four prospective case series studies, and six retrospective case series studies. Mean

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**Table 1. Search Strategies and Results From Different Electronic Databases**

<table>
<thead>
<tr>
<th>Database</th>
<th>Keywords</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>PubMed</td>
<td>#1 relaps* OR recurr* OR stability OR follow-up studies</td>
<td>108</td>
</tr>
<tr>
<td></td>
<td>#2 distraction* osteogenesis</td>
<td></td>
</tr>
<tr>
<td></td>
<td>#3 cleft OR cleft palate OR cleft lip palate</td>
<td></td>
</tr>
<tr>
<td></td>
<td>#4 #1 AND #2 AND #3</td>
<td></td>
</tr>
<tr>
<td>MEDLINE</td>
<td>#1 relaps$ OR recurr$ OR stability OR follow-up studies</td>
<td>105</td>
</tr>
<tr>
<td></td>
<td>#2 distraction$ osteogenesis</td>
<td></td>
</tr>
<tr>
<td></td>
<td>#3 cleft OR cleft palate OR cleft lip palate</td>
<td></td>
</tr>
<tr>
<td></td>
<td>#4 #1 AND #2 AND #3</td>
<td></td>
</tr>
<tr>
<td>Embase</td>
<td>#1 relaps$ OR recurr$ OR stability OR follow-up studies</td>
<td>63</td>
</tr>
<tr>
<td></td>
<td>#2 distraction$ osteogenesis</td>
<td></td>
</tr>
<tr>
<td></td>
<td>#3 cleft OR cleft palate OR cleft lip palate</td>
<td></td>
</tr>
<tr>
<td></td>
<td>#4 #1 AND #2 AND #3</td>
<td></td>
</tr>
<tr>
<td>ISI Web of Science</td>
<td>#1 relaps$ OR recurr$ OR stability OR follow-up studies</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td>#2 distraction$ osteogenesis</td>
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</tr>
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<td></td>
<td>#4 #1 AND #2 AND #3</td>
<td></td>
</tr>
<tr>
<td>EMB Reviews: Cochrane Central Register of Controlled Trials</td>
<td>#1 relaps$ OR recurr$ OR stability OR follow-up studies</td>
<td>5</td>
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<tr>
<td></td>
<td>#2 distraction$ osteogenesis</td>
<td></td>
</tr>
<tr>
<td></td>
<td>#3 cleft OR cleft palate OR cleft lip palate</td>
<td></td>
</tr>
<tr>
<td></td>
<td>#4 #1 AND #2 AND #3</td>
<td></td>
</tr>
<tr>
<td>EBM Reviews: Cochrane Database of Systematic Reviews, Database of Abstracts of Reviews of Effects, and ACP Journal Club</td>
<td>#1 relaps$ OR recurr$ OR stability OR follow-up studies</td>
<td>0</td>
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<tr>
<td></td>
<td>#2 distraction$ osteogenesis</td>
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<tr>
<td></td>
<td>#4 #1 AND #2 AND #3</td>
<td></td>
</tr>
<tr>
<td>HealthSTAR</td>
<td>#1 relaps$ OR recurr$ OR stability OR follow-up studies</td>
<td>84</td>
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<td></td>
<td>#2 distraction$ osteogenesis</td>
<td></td>
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<td></td>
<td>#3 cleft OR cleft palate OR cleft lip palate</td>
<td></td>
</tr>
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<td></td>
<td>#4 #1 AND #2 AND #3</td>
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<td>Total electronic databases searches</td>
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<tr>
<td>Duplicates</td>
<td></td>
<td>110</td>
</tr>
<tr>
<td>Final</td>
<td></td>
<td>310</td>
</tr>
<tr>
<td>Article</td>
<td>Study Design, Sample Size, Mean Age (years)</td>
<td>Type of Cleft, Surgical Procedure, Latency Period</td>
</tr>
<tr>
<td>---------</td>
<td>------------------------------------------</td>
<td>-----------------------------------------------</td>
</tr>
<tr>
<td>Aksu et al. 2010</td>
<td>P, CS 7 (3 F, 4 M) 21.56 ± 4.73 y</td>
<td>3 UCLP, 4 BCLP High LFI 5 days</td>
</tr>
<tr>
<td>Daimaruya et al. 2010</td>
<td>P, CT 6 (2 F, 4 M) 21.3 (range, 17.3–26)</td>
<td>6 UCLP Traditional LFI 3 days</td>
</tr>
<tr>
<td>Chua et al. 2010</td>
<td>P, RCT</td>
<td>Traditional LFI (segmental in 4 cases) 22 days</td>
</tr>
<tr>
<td>He et al. 2010</td>
<td>R, CS 17 (12 M, 5 F; G1:13, G2:4)</td>
<td>10 UCLP, 7 BCLP High LFI 3–4 days</td>
</tr>
<tr>
<td>Gürsoy et al. 2010</td>
<td>P, CS</td>
<td>6 UCLP, 3 BCLP, 4 CP 13 days</td>
</tr>
<tr>
<td>Huang et al. 2007</td>
<td>R, CS</td>
<td>2 UCLP, 4 BCLP High LFI 5 days</td>
</tr>
<tr>
<td>Rachmiel et al. 2006</td>
<td>P, CS 10 UCLP, 8 BCLP High LFI 4 days</td>
<td>10.5 (range, 9.4–12.3)</td>
</tr>
<tr>
<td>Kumar et al. 2006</td>
<td>R, CT 13 UCLP, 7 BCLP</td>
<td>Technique LFI 4 days</td>
</tr>
<tr>
<td>Harada et al. 2006</td>
<td>N/R</td>
<td>6 UCLP, 1 BCLP, 1 UCLA</td>
</tr>
<tr>
<td>Cho &amp; Kyung 2006</td>
<td>R, CS</td>
<td>7 UCLP, 2 BCLP LFI 5 days</td>
</tr>
<tr>
<td>Rachmiel et al. 2005</td>
<td>P, CS</td>
<td>7 UCLP, 5 BCLP</td>
</tr>
</tbody>
</table>
follow-up time was 3 years or more in five studies. Regarding the type of cleft in the treated patients, there were more than two times as many unilateral CLP patients treated as bilateral CLP patients (85 vs 41). High Le Fort I osteotomy was the most commonly used technique. The latency times ranged from 3 to 5 days and the consolidation periods ranged from 3 to 12 weeks.

Thirteen studies were finally selected and several of them showed consistent results. Only one randomized controlled clinical trial (RCT) was found. This RCT examined the long-term stability of maxillary advancement with DO in 22 patients greater than 16 years of age, and showed that DO is a stable technique in patients with CLP and that the maxilla moved forward and downward during the initial postoperative period. After a follow-up of 5 years, the A-point relapsed 8.24% horizontally. The relapse rate was lower in the DO group than in the conventional orthognathic surgery group after a follow-up of 5 years (8.24% vs 37%).

All of the finally included studies demonstrated DO as an effective technique for correction of maxillary hypoplasia in CLP patients. The maxilla was significantly advanced as indicated by the change in A-point. The mean horizontal movement was between 7 and 10 mm in five studies, followed by 10 and 15 mm in seven studies, and more than 15 mm in one study.

In the horizontal dimension, all included studies reported DO as a stable surgical technique for correction of maxillary hypoplasia in CLP patients. The horizontal relapse in A-point was less than 15% in eight studies and between 20% and 25% in four studies. Similarly, the horizontal relapse in SNA angle was less than 15% in four studies and between 20% and 35% in three studies. The two articles that were judged as high-quality articles reported less than 10% of horizontal relapse in A-point.

As for the vertical dimension, the movement was less than 3 mm in four studies and between 3 and 7 mm in three studies. However, the vertical relapse in A-point was variable between the studies. Two particular articles that were judged as high-quality articles reported more than 50% of vertical relapse in A-point.

In the randomized controlled trial published by Chua et al., the authors reported conventional Le Fort I advancement of CLP patients was 6.8 mm and a relapse rate was 37% (2.5 mm) after 5 years of follow-up. The findings of this systematic review suggest that DO can be expected to relapse about 15% (1.5 mm) after 10 mm of DO advancement in CLP patients. The lower relapse rate in the DO technique compared with
Le Fort conventional osteotomy may be explained by the gradual movement of the maxilla as well as the resistance of the external or internal distractor. These two factors reduce the unwanted backward and upward pull caused by the scarred tissues and muscles\(^{2,11}\).

The literature identified by the current systematic review suggested that the method of distraction was an important predictor of long-term stability. The long-term skeletal stability after DO was higher in the studies that used internal distracters than the studies that used external distracters. The rate of relapse was less than 10% in the three studies that used internal distracters, which may be related to the differences in the method of delivering forces from the distractor\(^{11,16,19}\).

In addition to the disharmony of occlusion, the presence of scarred palatal and lip tissues as well as posterior pharyngeal flaps from a prior surgery are expected to be the main reasons for relapse in CLP patients. Soft tissue scaring is known to be one of the greatest challenges facing surgical management of CLP patients, and has been suggested as an etiologic cause for the higher incidence of mid-face deficiency in CLP populations. Fibrotic scar tissue may restrict the movement of the maxilla and is thought to be significant for relapse to the preadvanced position\(^{2,11,37}\).

Finally, a well-conducted and clearly reported randomized controlled clinical trial comparing the results of conventional orthognathic surgery and DO in patients with CLP would be very useful in assessing the differences in the skeletal and dental stability between the two techniques in short-term and long-term follow-up.

### Table 3. Methodologic Score for the Included Studies\(^a\)

<table>
<thead>
<tr>
<th>A. Objective—clearly defined (✓)</th>
<th>B. Population—adequately described (✓)</th>
<th>C. Sample size—considered adequate (✓)</th>
<th>D. Selection criteria—clearly described (✓), adequate (✓)</th>
<th>E. Randomization or consecutive selection—stated (✓)</th>
<th>F. Follow up length—clearly described (✓)</th>
<th>G. Timing—prospective design (✓)</th>
<th>H. Type of study—RCT (✓✓✓), CT (✓✓), CS (✓)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. Measurement method—mentioned (✓), appropriate (✓)</td>
<td>J. Blinding—stated (✓)</td>
<td>K. Reliability—described (✓)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Statistical Analysis (4 ✓)

| L. Dropouts—accounted (✓) |
| M. Statistical analysis—appropriate (✓) |
| N. Presentation of data—exact P value stated (✓), variability measures (SD or CI) stated (✓) |

\(^{a}\) Maximum number of ✓'s = 19.

\(^{b}\) RCT indicates randomized clinical trial; CT, clinical trial; and CS, case series.

### Table 4. Methodologic Score of Selected Articles\(^a\)

<table>
<thead>
<tr>
<th>Article</th>
<th>Study Design</th>
<th>Study Measurements</th>
<th>Statistical Analysis</th>
<th>% of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
</tr>
<tr>
<td>Aksu et al.(^a) 2010</td>
<td>✓</td>
<td>✓</td>
<td>x</td>
<td>✓</td>
</tr>
<tr>
<td>Daimaruya et al.(^a) 2010</td>
<td>✓</td>
<td>✓</td>
<td>x</td>
<td>✓</td>
</tr>
<tr>
<td>Chua et al.(^a) 2010</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>He et al.(^a) 2010</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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<tr>
<td>Günsoy et al.(^a) 2010</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Huang et al.(^a) 2007</td>
<td>✓</td>
<td>✓</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Rachmiel et al.(^a) 2006</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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<tr>
<td>Kumar et al.(^a) 2006</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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<tr>
<td>Harada et al.(^a) 2006</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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<tr>
<td>Cho and Kyung(^a) 2006</td>
<td>✓</td>
<td>✓</td>
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<tr>
<td>Rachmiel et al.(^a) 2005</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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<tr>
<td>Figueroa et al.(^a) 2004</td>
<td>✓</td>
<td>✓</td>
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<td>✓</td>
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<tr>
<td>Suzuki et al.(^a) 2004</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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</tr>
</tbody>
</table>

\(^{a}\) (A to N: methodologic criteria in Table 3); X indicates did not fulfill the methodologic criteria (0 check point); ✓, fulfilled satisfactorily the methodologic criteria (1 check point); ✗, fulfilled partially the methodologic criteria (0.5 check point).

\textit{Angle Orthodontist, Vol 82, No 6, 2012}
The relapse rate is higher in DO with an external distracter than DO with an internal distracter.

**REFERENCES**


