The skeletal stability of one-piece Le Fort 1 osteotomy to advance the maxilla
Part 2. The influence of uncontrollable clinical variables

G.R. Hoffman\textsuperscript{a,1}, P.A. Brennan\textsuperscript{b,c,*}

\textsuperscript{a}Princess Alexandra Hospital, Brisbane, Qld, Australia
\textsuperscript{b}Maxillofacial Department, Queen Alexandra Hospital, Portsmouth, Cosham, UK
\textsuperscript{c}Portsmouth Hospitals NHS Trust, Portsmouth PO6 3LY, UK

KEYWORDS
Le Fort 1 osteotomy; Skeletal stability; Maxilla; Clinical variables

Summary The stability of orthognathic surgery has been the subject of numerous publications over the last 20 years. It is now apparent that studies must pay attention to the homogeneity of the patients investigated and in particular, surgical techniques. In Part 2 of our study of 45 patients who had a uniform one-piece maxillary advancement with rigid fixation to advance the maxilla, we found that uncontrollable variables, including patients age, sex, the degree of advancement, and simultaneous mandibular advancement, had no effect on post-operative skeletal stability.

Introduction The aim of orthognathic surgery is to correct a dental malocclusion and facial deformity. These occlusal-based facial deformities in essence are assessed and managed according to symmetry and profile evaluations. The first part of our study acknowledged that the attainment of three-dimensional skeletal stability after corrective jaw surgery remains a problem during the post-surgical period. Recent studies of post-operative skeletal stability after such surgery have highlighted the need to promote, where practical, the elimination of clinical variables.\textsuperscript{1} This is to ensure that the investigation is based on a homogenous group of patients.

The second part of this study evaluated retrospectively the influence of uncontrollable clinical variables on the post-surgical stability of one-piece Le Fort 1 osteotomy to advance the maxilla.

Patients and methods We studied 45 patients who were treated for horizontal maxillary deficiency were studied. Patient selection, surgical technique, follow up and cephalometric analysis have previously been documented in Part 1. Pearson’s product moment correlation and tailed paired \textit{t} tests were used to...
Table 1: Mean (S.D.) of surgical changes (mm) and stability by sex of patient.

<table>
<thead>
<tr>
<th>Sex</th>
<th>Number of patients</th>
<th>Overall change</th>
<th>Change at 6 weeks</th>
<th>Change at 12 months</th>
<th>Short-term relapse</th>
<th>Long-term relapse</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>13</td>
<td>8.6 (3.65)</td>
<td>8.4 (3.9)</td>
<td>8.1 (4.3)</td>
<td>-0.20 (0.40)</td>
<td>-0.50 (0.97)</td>
</tr>
<tr>
<td>Female</td>
<td>32</td>
<td>6.9 (2.9)</td>
<td>6.5 (3.0)</td>
<td>6.1 (2.5)</td>
<td>-0.50 (0.80)</td>
<td>-0.80 (1.05)</td>
</tr>
<tr>
<td>Total</td>
<td>45</td>
<td>7.4 (3.3)</td>
<td>7.0 (3.3)</td>
<td>6.7 (3.2)</td>
<td>-0.40 (0.70)</td>
<td>-0.70 (1.03)</td>
</tr>
</tbody>
</table>

There were no significant associations.

Table 2: Crude and sex- and age-adjusted mean changes over time in 45 patients.

<table>
<thead>
<tr>
<th></th>
<th>Crude mean (S.E.)</th>
<th>S.D.</th>
<th>Adjusted mean (S.E.)</th>
<th>S.D.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surgical change</td>
<td>7.42 (0.48)</td>
<td>3.2</td>
<td>7.78 (0.53)</td>
<td>3.5</td>
</tr>
<tr>
<td>Remaining at 6 weeks</td>
<td>7.04 (0.50)</td>
<td>3.3</td>
<td>7.45 (0.54)</td>
<td>3.6</td>
</tr>
<tr>
<td>Remaining at 12 months</td>
<td>6.71 (0.48)</td>
<td>3.2</td>
<td>7.13 (0.54)</td>
<td>3.6</td>
</tr>
</tbody>
</table>

find out whether there were any correlations or differences between patient variables and stability. Probabilities of less than 0.05 were regarded as statistically significant.

Power of study

With the observed standard deviation of the distribution of long-term differences from surgical change of 1.031 and with 45 patients studied, it was possible to detect differences over time of 0.50 or greater with 90% power at the 95% significance level.

Results

All results are shown in Tables 1–4. There were no correlations found between patient’s ages and surgical change and stability. There were no statistically significant associations between male and female sex and surgical change ($P = 0.11$), short-term stability ($P = 0.08$), or long-term stability ($P = 0.09$) (Table 1). Accounting for differences in age and sex in the repeated measures analysis of variance did not alter the conclusion that there were significant changes over time (adjusted analysis $F_{2,41} = 3.04$, $P = 0.06$) (Table 2).

Table 3 shows the influence of simultaneous mandibular advancement on maxillary relapse. While this revealed an overall lesser advancement for patients who underwent combined maxillary and mandibular advancement (6.2 mm compared with 8.2 mm), there was no significant association between maxillary relapse and the inclusion of mandibular advancement ($P = 0.27$). However, clinically the relapse over the 12-month period for combined maxillary and mandibular advancement was twice that of maxillary advancement alone (1.2 mm compared with 0.6 mm), although this was of little clinical significance.

Table 4 shows the influence of the amount of maxillary advancement on maxillary relapse. Once

Table 3: Influence of simultaneous mandibular advancement on relapse in the maxilla ($P = 0.27$).

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Number of patients</th>
<th>Mean (S.E.)</th>
<th>S.D.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maxilla only</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
<td>8.3 (0.6)</td>
<td>3.3</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>8.0 (0.6)</td>
<td>3.3</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>7.6 (0.58)</td>
<td>3.2</td>
</tr>
<tr>
<td>Maxilla and mandible</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
<td>6.2 (1.2)</td>
<td>4.6</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>5.6 (1.22)</td>
<td>4.7</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>5.0 (1.16)</td>
<td>4.5 (all skewed)</td>
</tr>
</tbody>
</table>

Table 4: Influence of the amount of maxillary advancement on relapse in the maxilla.

<table>
<thead>
<tr>
<th>Distance (mm)</th>
<th>Number of patients</th>
<th>Mean (S.E.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤4.8</td>
<td>11</td>
<td>3.2 (0.56)</td>
</tr>
<tr>
<td>4.9–7.1</td>
<td>12</td>
<td>2.9 (0.53)</td>
</tr>
<tr>
<td>7.2–9.4</td>
<td>10</td>
<td>4.9 (0.45)</td>
</tr>
<tr>
<td>≥9.5</td>
<td>12</td>
<td>7.5 (0.54)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6.9 (0.52)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>11.1 (0.39)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10.6 (0.37)</td>
</tr>
</tbody>
</table>
again, there was no evidence to suggest that in-
stability over time was any greater for one surgical
change group compared to any other (P = 0.9).
However, clinically for surgical change less than
4.8 mm, the relapse was only half as much. Further
to this, the relapse for advancements greater than
4.9 mm was similar regardless of the amount of
movement.

Discussion

The 45 patients in this study had a one-piece Le
Fort 1 osteotomy without bone grafting and fixed
internally to advance the maxilla, combined with
orthodontic detailing. Fifteen patients also under-
went simultaneous mandibular advancement.

The requirement for bone grafting and its
contribution to stability

This remains a contentious issue. Theoretically,
rigid internal fixation should, at the very least, af-
ford short-term (and, ideally long-term) stability.
However, if there is poor bone approximation at
the osteotomy site, union may be delayed or even
fail to occur. Relapse in such circumstances might
be expected. Autogenous bone grafting may help
to accelerate bony union, act as a mechanical stop,
provide a matrix for secondary reconstruction and
prevent soft tissue herniation into the osteotomy.2

Wilmar3 showed that no significant difference
existed between 16 graft maxillary osteotomies
and 43 which were non-grafted, in relation to
the potential for post-operative horizontal and/or
vertical change. A mean surgical advancement of
7.2 mm was identified. In contrast, Araujo et al.4
claimed improved stability of total maxillary ad-
vancement with bone grafts to a mean of 6.0 mm.
Overall relapse ranged from 31—68% without bone
grafts, compared to 0—5% with grafts. A shortcom-
ing of these two studies is that they both comprised
a heterogeneous cohort, which included idiopathic,
cleft and post-traumatic deformities as well as
dentulous pre-prosthetic deformity.

Nevertheless, their conclusions would seem to
support the contention of bone grafting for maxil-
lar advancements of more than 6.0 mm and cer-
tainly for those in excess of 10.0 mm.

Egbert et al.5 selected 25 patients who under-
went one-piece maxillary advancement osteotomy
(without vertical change) utilising a bone graft. Al-
though 13 patients that received rigid internal fix-
ation appeared to have somewhat better stability
than 12 patients receiving combined wire osteosyn-
thesis and fixation, the difference was not statisti-
cally significant.

However, the importance of the role of bone
grafting could not be deduced because the entire
cohort had bone graft placed at the osteotomy site.

Kerawala et al.6 assessed the influence of bone
grafting on Le Fort 1 osteotomy in patients without
clefts. Appropriately they excluded 77 of their origi-
nal cohort of 189 patients on the basis of incomplete
records or cleft, segmental or syndromal surgery.
Of the remaining 112 patients, 40 involved the max-
illa in isolation and 72 had bimaxillary procedures.
Unfortunately the 112 maxillary procedures again
included a heterogenous group comprising anterior,
superior or inferior repositioning. Numerical values
for each of the subgroups were not included for as-
essment. Superior repositioning proved to be the
most stable movement. Advancements were in the
order of 4.0 mm with relapse of 0.1 mm (2.5%). They
concluded that the anteriorly repositioned maxilla
may be more stable if a bone graft is used.

In our study, the maxilla was advanced an aver-
age of 7.42 mm (range 1.8—15.3 mm). The maxillae
were not bone grafted. There were no cases of de-
layed or non-union.

Does the degree of advancement contribute
to relapse?

Louis et al.7 studied 20 patients retrospectively
who had rigidly fixed maxillary advancement with-
out bone grafts in whom underwent bimaxillary ad-
vancement to treat (non-orthodontic) obstructive
sleep apnoea. In order to assess whether the mag-
nitude of advancement correlated with the magni-
itude of relapse they divided their cohort into three
groups (data are mean and S.D.): less than 6 mm
(4.7 ± 0.8; n = 4); 7—9 mm (8.2 ± 0.9; n = 9) and
greater than 10 mm (12.3 ± 2.8; n = 7).

The mean and S.D. relapses identified for each
group were 0 (0.6 mm) in the first group, 0.7
(1.5 mm) in the second and 1.9 (1.8 mm) in the
third. The numbers in each group were small, and
they concluded that statistically there was no sig-
nificant difference in measured relapse. However,
it would seem likely that the greater the advance-
ment the greater the relapse, not withstanding its
clinical insignificant nature. Of note was that two
patients “relapsed” in a positive direction (1.5
and 2.5 mm, respectively) and one patient relapsed
5.0 mm. These results are clearly clinically signif-
icant and undoubtedly impact on the statistical
analysis. The mean surgical change in our study was
7.4 mm (1.8—15.3 mm). The relapse rate therefore
is equivalent to the second group in their study.7
The relapse therefore seems to be comparable in maxillary advancement without bone grafts.

Do the age and the sex of the patient contribute to relapse?

Phillips et al. evaluated 60 patients who underwent maxillary surgery. Thirty had one-piece impaction. They found that the maxilla tended to intrude slightly during the fixation period. In patients older than 19 years, there was no tendency for the maxilla to move downward in the follow-up period. In contrast, in patients less 19 years, there was an average downward movement of 2 mm, which was attributed to late vertical growth.

Bishara et al. studied 31 patients who underwent maxillary superior repositioning, and found no significant differences between the younger (less than 20 years) and older patients. In the same study, comparisons of the absolute and relative surgical changes (day 1), during fixation (5 weeks) and during postfixation (5 months) did not differ significantly when comparing the sex of the patient. There were 12 patients who had correction of anterior open bite. There were also no significant differences between surgical teams and differing durations of fixation.

Does the influence of simultaneous mandibular advancement compromise the stability of the maxilla?

The Le Fort 1 is the most frequently performed midfacial osteotomy. We have increasing tended to do maxillary advancement in isolation to treat Class III patients, obviating the need for a simultaneous mandibular set back procedure.

Historically, the most frequent indication for simultaneous two-jaw surgery has been a combination of vertical maxillary excess (with or without open bite) together with horizontal mandibular deficiency.

The actual degree of mandibular advancement has generally been somewhat less than expected due to the associated autorotation. In the literature it is being increasingly undertaken without orthodontics to treat obstructive sleep apnoea patients. This has resulted in larger mandibular advancements due to:

(a) the initial antero-posterior discrepancy;
(b) the further discrepancy resulting from simultaneous maxillary advancement;
(c) a lack of autorotation because there is no planned vertical change in position of the maxilla.

What has been the effect of mandibular advancement on the stability of the maxilla in treating the Class II dentofacially retrusive patient? It has been stated that bimaxillary surgery may be more stable due to a physiologic splinting of the jaws that is different from that in isolated maxillary surgery, where the mandible remains intact. The tendency for mandibular relapse can be offset by the application of light Class II intermaxillary elastic traction to maintain the antero-posterior position of the mandible, particularly during osseous consolidation at the osteotomy site. The vector and force generated by such manoeuvres seem to have no impact on the spatial position of the maxilla.

What is the effect of orthodontic treatment on the stability of the maxilla?

The principle of combined surgical and orthodontic management of dentofacial deformity has been to expand the facial profile whilst correcting the relationship between the dentition and their respective skeletal bases by orthodontic decompensation. As orthodontic treatment has relied on making the incisors upright rather than flaring them, small amounts of skeletal relapse can be offset by post-surgical orthodontic detailing. Theoretically, there should be no effect on the stability of the skeletal elements.

What is the role of growth on the stability of the maxilla?

Adverse and/or late growth of the mandible in patients with a true skeletal III tendency may contribute to the re-establishment of a negative overjet but should play no role in effecting maxillary stability.

Part 2 of the current study revealed that uncontrollable variables, including patients age, sex, together with the magnitude of advancement and the influence of simultaneous mandibular advancement, had no effect on the post-operative skeletal stability in orthodontically prepared, rigidly fixed one-piece Le Fort 1 osteotomy without bone grafting to advance the maxilla.

References

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