Nasolabial esthetics after Le Fort I osteotomy and V-Y closure: A statistical evaluation

The Le Fort I osteotomy results in predictable long-term effects. The soft tissues, however, can be difficult to control because of considerable variation in their adaptation. Several adverse reactions can take place, including thinning and lateral retraction of the lip, accentuation of the nasolabial groove, reduced vermilion exposure, and increase of the nasolabial angle. In this study on 51 selected patients, the V-shaped wound in the vestibule of the maxilla after the Le Fort I osteotomy was closed with a "Y," with the base of the "Y" in the midline of the upper lip (V-Y closure). Forward multiple regression analysis was calculated for each bony landmark. Regression equations were formulated if $P < .05$. The equation with the bony point with the highest $r^2$ value was considered the most important independent variable. The selected independent variables were used to form 4 subgroups with identical vectors of movements: impaction, advancement, impaction and advancement, and dorsal impaction. In these 4 subgroups, forward multiple regression analysis was used to select equations with the highest $r^2$ value ($P < .05$). The selected equations demonstrated that a V-Y plasty as single soft tissue procedure suffices only in advancement cases, and only if the nose does not need additional upward rotation. In the other 3 subgroups, additional procedures are necessary, such as alar cinch suture, reduction of the anterior nasal spine, or grinding of the paranasal area in order to prevent the above-mentioned adverse soft tissue changes. (Int J Adult Orthod Orthognath Surg 2002;17:29–39)
the measurement of overbite, overjet, and maximum alar width, an orthopantomogram (OPT), a standardized lateral cephalogram, full photographic documentation, and plaster of parts casts. All patients had received preoperative and postoperative orthodontic treatment. They were followed at regular time intervals: after finishing the preoperative orthodontic treatment, as well as at 3 months and 1 year postoperatively. At these appointments, the same investigations were done as in the preoperative examination. The lateral cephalograms were made at a focus-patient distance of 6 m, and a patient film distance of 0.40 m. The cephalograms were printed on Agfa curix films (Henry Schein bv, Utrecht, The Netherlands). All lateral cephalograms were digitized by one investigator (MSMM) using Dentofacial planner 5.1 (Dentofacial Software, Toronto, Ontario, Canada), using a Hipad digitizer (Houston Instruments, division of Ametek, Belgium) and an ADI microscan computer (ADI computer, Taipei, Taiwan). A custom-made analysis was done for all relevant points that could be found through the use of an X-Y system centered in the sella. The x axis runs from sella through nasion plus 7 degrees, which is a reliable landmark and a good alternative for the Frankfort horizontal line\(^2\) (Fig 1). The y axis runs down from the sella; therefore, the vertical measurements are in the negative part of the X-Y system. Negative values move in a cranial direction and positive values in a caudal direction.

Baumrind and Frantz\(^1\) evaluated the reliability of common cephalometric landmarks: Both sella and nasion were rated extremely high. The soft tissue points measured were pronasale (Pn), subnasale (Sn), labrale superior (Ls), and stomion superior (Sts). The bony points measured were A point (A), I point (I), and posterior nasal spine (PNS). The cephalometric points are depicted in Fig 1. From every point mentioned, the X direction as well as the Y direction could be determined. When measuring the X direction, the letter x is added; when measuring the Y direction, the letter y is added to the soft or hard tissue points. The differences between the points measured preoperatively and 1 year postoperatively were calculated. The 3-month data.
were not used because edema might have still been present at that time.

Methodological error

The error of the method was assessed by digitizing the randomly selected lateral cephalograms of 20 patients a second time after 4 months (Table 1). The difference between these 2 measurements was considered to be the error of method.

Final selection criteria

Four subgroups were defined:

1. Impaction group. The movement at point Ax had to be less than 2 mm, whereas point Ay had to be greater than 2 mm. This group contained 11 patients.
2. Advancement. The movement at point Ax had to be greater than 2 mm, whereas the movement at point Ay had to be less than 2 mm. This group contained 9 patients.
3. Impaction and advancement. Point Ax had to move more than 2 mm, as did point Ay. This group contained 17 patients.
4. Dorsal impaction. The movement at the posterior nasal spine in the Y direction (PNSy) had to be 2 mm greater than the movement at point Ay. This group contained 14 patients.

A total sample of 51 patients in 4 subgroups with similar vectors of movements were thus eligible for selection.

Statistical analysis

Descriptive statistics were calculated for each landmark covering the preoperative to 1-year postoperative time period. The equation for the regression analysis used was: \( A = bC + \text{Intercept} \). In this equation, \( A \) = the soft tissue changes (dependent variable), \( C \) = the movement of the bony point (independent variable), \( b \) = the coefficient indicating the percentage of change of the soft tissues after 1 mm of bony movement, and \( \text{Intercept} \) demonstrates the change of the soft tissue after 0 mm movement of the bone. Thus, the intercept demonstrates the changes of the soft tissues by the operation itself.

A regression analysis was performed with the bony points A, I, and posterior nasal spine (PNS) as independent variables and the soft tissue points mentioned above as dependent variables. The relationships between the vector of the skeletal movements and changes at labrale in X and Y direction (Lsx and Lsy), stomion in X and Y direction (Stx and Sty), subnasale in X and Y
direction (Sn and Sny), pronasale in X and Y direction (Pnx and Pny), and the maximal alar width (MAW) were described with forward multiple linear regression analysis, and the calculated Pearson correlation coefficients (r). The $r^2$ value was calculated: an $r^2$ value of 1 indicates 100% correlation, whereas an $r^2$ square value of 0 indicates no correlation and thus maximal variation. $P$ values < .05 were considered relevant for formulating a regression equation. In order to find out which were the most relevant bony points, a forward multiple linear regression analysis was performed on the equations with $P$ values < .05. The different bony points that defined 1 soft tissue point were selected. The equation with the bony point with the highest $r^2$ value was considered the most important independent variable and was therefore selected. This first selection was done on the whole group of 51 patients. Thereafter, the groups were divided in 4 groups with similar vectors of movement as described above. In these 4 subgroups, forward multiple regression analysis was used to select the equation with the highest $r^2$ value. The statistical package used was SPSS 9 for MS Windows (SPSS, Chicago, IL), using a Dell computer.

Results

Fifty-one patients were included in this study. The mean age was 24.6 years from a range of 18 to 42 years. There were 31 females and 20 males.

The forward multiple regression analysis was used on the group of 51 patients. The different bony points defining each relevant soft tissue point are listed in Table 2. The bony point mentioned first for each soft tissue point is the most influential bony point with the highest $r^2$ and thus the most relevant point for that soft tissue point. All $P$ values < .01.

The results of the 4 subgroups will be correlated with the independent bony points. Clinical relevant equations ($P < .05$) are mentioned in Table 3.

Impaction (n = 11)

Mean impaction at A-point was 5.5 mm, whereas point A moved forward only 0.2 mm (SD = 1.1). Thus, in this group near full impaction without advancement was achieved.

Labial changes. A significant increase of stomion superior was observed ($P = .04$). The best fitting regression equation for stomion superior was:

\[ Stsy = 1.33Ay - 1.49 PNSy - 0.38 \]
\[ Stsx = 0.80 Ix + 0.89. \]

By every mm upward movement of point A, stomion followed by 1.33 mm. The ratio of PNSy was –1.49. Hence in impaction cases, the movement slightly lengthened the upper lip. Yet initially there was shortening of the lip, as indicated by the intercept of –0.38, due to the operation itself.

Nasal changes. No statistically significant changes of the nose were found in impaction cases.

Advancement (n=9)

Mean advancement at A-point (Ax) was 2.6 mm (SD = 1.4). Mean impaction (Ay) was 0.4 mm (SD = 1.5).

Labial changes. No significant correlation was found between stomion superior x and A-point. However, statistically significant correlations were found at the position of labrale superior:

\[ Lsx = 0.65Ix - 0.06 \]
\[ Stsy = -0.33Ix + 0.96 \]

Thus, for every mm forward movement of Ix, the Lsx moved forward 0.65 mm. There was almost no effect on Lsx of the operation itself as the intercept was nearly zero. Forward movement of I point gave an upward movement of stomion. Hence the decrement of vermilion exposure.

Nasal changes. Horizontal movement of the maxilla had several statistically significant effects on the nose. The best fitting regression equations proved to be:

\[ Snx = 0.64Ax - 0.05 \]
\[ Sny = -0.38I + 0.56 \]
\[ Pnx = 0.34Ax + 0.001 \]
\[ Pny = -0.29I - 0.30 \]
Table 2  Forward multiple regression analysis*

<table>
<thead>
<tr>
<th>Dependent</th>
<th>Independent 1</th>
<th>r²†</th>
<th>Independent 2</th>
<th>Independent 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stsx</td>
<td>Ix</td>
<td>0.52</td>
<td>Iy</td>
<td>Ax</td>
</tr>
<tr>
<td>Stsy</td>
<td>Ay</td>
<td>0.41</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lsx</td>
<td>Ix</td>
<td>0.58</td>
<td>Ax</td>
<td>Ay</td>
</tr>
<tr>
<td>Lsy</td>
<td>Ay</td>
<td>0.35</td>
<td>Ix</td>
<td></td>
</tr>
<tr>
<td>Snx</td>
<td>Ax</td>
<td>0.33</td>
<td>Ay</td>
<td></td>
</tr>
<tr>
<td>Sny</td>
<td>Ix</td>
<td>0.19</td>
<td>Ay</td>
<td></td>
</tr>
<tr>
<td>Pnx</td>
<td>Ax</td>
<td>0.21</td>
<td>Ay</td>
<td></td>
</tr>
<tr>
<td>Pny</td>
<td>Ix</td>
<td>0.20</td>
<td>Ay</td>
<td></td>
</tr>
</tbody>
</table>

*For each dependent variable, the most influential independent variable is selected first. The second best is selected thereafter. The third best is mentioned in the last column.
†r² value is mentioned only for the first independent variable.

For all equations: P < .01, n = 51.

Table 3  Regression equations for P < .05 using forward multiple regression analysis.

<table>
<thead>
<tr>
<th></th>
<th>r²</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impaction (n = 11)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stsy = 1.33Ay – 1.49PNSy – 0.38</td>
<td>0.66</td>
<td>.013</td>
</tr>
<tr>
<td>Stsx = 0.80Ix + 0.89</td>
<td>0.48</td>
<td>.018</td>
</tr>
<tr>
<td>Advancement (n = 9)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lsx = 0.65Ix – 0.06</td>
<td>0.82</td>
<td>.001</td>
</tr>
<tr>
<td>Stsy = -0.33Ix + 0.96</td>
<td>0.46</td>
<td>.04</td>
</tr>
<tr>
<td>Snx = 0.64Ax – 0.05</td>
<td>0.45</td>
<td>.04</td>
</tr>
<tr>
<td>Sny = -0.38Ix + 0.56</td>
<td>0.61</td>
<td>.02</td>
</tr>
<tr>
<td>Pnx = 0.034Ax + 0.001</td>
<td>0.46</td>
<td>.04</td>
</tr>
<tr>
<td>Pny = -0.29Ix – 0.30</td>
<td>0.50</td>
<td>.03</td>
</tr>
<tr>
<td>Impaction and advancement (n = 17)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lsx = 0.34Ix + 0.49PNSx +0.61</td>
<td>0.50</td>
<td>.001</td>
</tr>
<tr>
<td>Lsy = -0.31Ay + 0.45Iy + 0.45</td>
<td>0.33</td>
<td>.02</td>
</tr>
<tr>
<td>Stsx = 0.54Ix + 0.31PNSy + 0.08</td>
<td>0.69</td>
<td>.001</td>
</tr>
<tr>
<td>Stsy = -0.27Iy + 0.50Iy + 0.39</td>
<td>0.35</td>
<td>.01</td>
</tr>
<tr>
<td>Sny = -0.30Ix + 0.71</td>
<td>0.33</td>
<td>.02</td>
</tr>
<tr>
<td>Dorsal impaction (n = 14)</td>
<td></td>
<td></td>
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<tr>
<td>Lsx = 0.47Ax – 1.55</td>
<td>0.47</td>
<td>.007</td>
</tr>
<tr>
<td>Lsy = 1.23Ay + 1.08</td>
<td>0.71</td>
<td>.001</td>
</tr>
<tr>
<td>Stsx = 0.47Ax – 2.06</td>
<td>0.47</td>
<td>.007</td>
</tr>
<tr>
<td>Stsy = 1.12Ay – 0.13</td>
<td>0.69</td>
<td>.001</td>
</tr>
<tr>
<td>Pnx = 0.46Ax – 0.67</td>
<td>0.37</td>
<td>.021</td>
</tr>
<tr>
<td>Pny = 1.03Ay + 0.53</td>
<td>0.46</td>
<td>.008</td>
</tr>
<tr>
<td>Snx = 0.38Ax – 0.23</td>
<td>0.44</td>
<td>.010</td>
</tr>
<tr>
<td>Sny = 1.19Ay + 0.85</td>
<td>0.67</td>
<td>.001</td>
</tr>
</tbody>
</table>

If 2 independent (bony) points define the same variable, the equation with the lowest P value is selected.
Vertical movements of the soft tissue points of the nose, ie, Sn and Pn, had a negative coefficient and were influenced by horizontal movements of I-point and A-point. Therefore, the points Sn and Pn moved in a cranial direction. Sn and Pn were significantly influenced by the horizontal movement of A-point. When this independent point moved forward, Sn and Pn did the same to a lesser degree. As in all these equations, the intercept was small; there was no significant influence on the soft tissues by the operation itself.

**Impaction and advancement (n=17)**

**Labial changes.** The best-fitting equations were:

\[
L_{sx} = 0.34I_x + 0.49PNS_x + 0.61 \\
L_{sy} = -0.31I_x + 0.45I_y + 0.45 \\
St_{sx} = 0.54I_x + 0.31PNS_y + 0.08 \\
St_{sy} = -0.27I_x + 0.50I_y + 0.39
\]

For horizontal movements of the maxilla as indicated by I-point and posterior nasal spine, stomion and labrale superior followed to a lesser degree. The intercept showed that the operation itself caused some minor forward movement. Vertical soft tissue movements were influenced by horizontal as well as vertical movements of I-point. There was some lip lengthening, as indicated by the intercepts of 0.45 and 0.39. The vertical changes of labrale superior and stomion superior were almost equally influenced by the bony movements; therefore, vermilion exposure was not changed. The horizontal hard tissue movement influenced the soft tissue changes to a lesser degree than the vertical hard tissue movement, as the ratio coefficients of the former were smaller than those of the latter.

**Nasal changes.** The significant equation that described the nose was:

\[
S_{ny} = -0.30I_x - 0.71
\]

**Dorsal impaction**

Mean impaction at A-point (Ay) was 0.8 mm (SD = 2.1 mm); for the posterior nasal spine (PNSy), impaction was 4.4 mm (SD = 1.9 mm). Advancement at A-point (Ax) was 0.4 mm (SD = 3.0 mm).

**Labial changes.** The best-fitting formulas for changes at the lip are given by:

\[
L_{sx} = 0.47A_x - 1.55 \\
L_{sy} = 1.23A_y + 1.08 \\
St_{sx} = 1.12A_y - 0.13
\]

The intercept of the first 2 formulas, describing horizontal changes of labrale superior and stomion superior, was negative; hence there was thinning of the upper lip and loss of lip projection, because the operation itself moved the lip structures in a dorsal direction. However, the ratio coefficient was nearly equal, so the forward movement of A-point had an identical effect on labrale and stomion.

The vertical changes of the upper lip initially demonstrated that Ls moved in a caudal direction as the intercept was 1.08, whereas St moved 0.13 mm upward. When A-point moved upward, Ls moved upward more than St because the coefficient of Ls was greater than the ratio coefficient defining for St. Therefore, the potentially resulting loss of vermilion exposure from the operation was counteracted by the upward movement of A-point.

**Nasal changes.** The nasal changes were best illustrated by the following formulas:

\[
S_{nx} = 0.38A_x - 0.23 \\
P_{nx} = 0.46A_x - 0.67 \\
P_{ny} = 1.03A_y + 0.53 \\
S_{ny} = 1.19A_y + 0.85
\]

Significant nasal changes in cases of dorsal impaction were influenced by A-point. The vertical movement of A-point had a greater ratio coefficient than the horizontal movements. Pn and Sn moved forward and upward, although the operation itself caused some caudal movement, as the intercept was +0.53 and +0.85. However, this movement was counteracted by the upward movement of A-point.

**Maximal alar width**

In all 4 groups of movement, no statistically significant effects were found regarding the maximal alar width.
Discussion

General remarks

Soft tissue management after maxillofacial osteotomies is important for the final esthetic result. Extensive additional soft tissue procedures are problematical because edema after the osteotomy makes proper judgment during handling of the soft tissues impossible. In addition, during extensive procedures on the nose, the nasal tube has to be changed in an oral intubation, compromising nasal surgery considerably. We therefore think that nose surgery is not possible simultaneously with a Le Fort I osteotomy. It is, however, possible with sagittal splitting procedures or genioplasties.

Soft tissue procedures on the nose, which can be performed simultaneously with a Le Fort I osteotomy, are the alar cinch suture, resection of the anterior nasal spine, wedge excision of the alar base, grinding of the paranasal area, and thinning of the columella. In this sample of patients, only a V-Y plasty was performed in order to find out for which kind of maxillary movement a V-Y plasty suffices in creating a pleasing result. Therefore, 4 different groups were composed of patients who had only a Le Fort I osteotomy performed and had similar vectors of movement.

Due to proper selection of the subgroups, only small numbers of patients could finally be included. Because there was considerable variation between patients, only the equations with $P$ values $<0.05$ were used here. The Pearson's correlation coefficient $r$ was not used for further selection of equations, although a higher coefficient indicated a stronger correlation. The $r^2$ shown in Table 3 illustrates to what extent the equation explains the dependent variable and also, therefore, describes the variation. An $r^2$ of 1 means that there is no variation and every dependent point can be predicted by the equation. An $r^2$ of 0 means maximal variation; in these cases, no equation can be formulated.

The method of error as described in Table 2 was also used by Van Butsele et al, who found a mean error of all points in the X direction as 0.43 mm and for the Y direction as 0.42 mm. These results are comparable with ours. We found the mean error for the X direction to be 0.38 mm and for the Y direction to be 0.46 mm. Although a different software and digitizer were used here, the magnitude of the error seems to be in the same range. We therefore think that the method is reliable and can at least be used to compare these results with the results found in the literature. Betts et al used the standard error of the mean and found for linear measurements $0.67 \pm 0.09$ mm. Radney and Jacobs also used the standard error of the mean by measuring every landmark 3 separate times. After calculating the average deviation of the mean for each landmark, they estimated the overall mean error as 0.24 mm. In that study, however, every measurement was done by hand, without a computer. In this study it seemed that for the different kind of maxillary movements, different independent variables were selected by the computer for the same soft tissue point for formulating equations. Hence we looked at the independent points of all 51 patients with the highest $r^2$ value in order to find out for which bony point the highest correlation could be found for each soft tissue point. Using forward multiple regression analysis, the computer chose the independent point with the strongest $r^2$ value (Table 1). Posterior nasal spine did not seem to play a role of importance. It was interesting to note that the greatest influences on the soft tissue points of the nose were all bony movements of A-point and I-point in a horizontal direction. The greatest influences on the vertical movements of the soft tissue points of the nose were all horizontal bony movements of A-point. Horizontal soft tissue movements of the upper lip were influenced by horizontal movements of I-point with $r^2$ values of 0.52 and 0.58 (Table 2, first and third rows). The vertical movements of the upper lip were mainly influenced by vertical bony movements of A-point. For horizontal movements of the lip, I-point seemed to have had the greatest influence, whereas for vertical movements, A-point had the greatest influence on the upper lip.
Discussion of the several directions of movement

**Impaction.** Three equations could be formulated which met the criteria devised. Two equations defined structures of the upper lip. The vertical movement of stomion superior was defined by A-point and posterior nasal spine in the equation \( \text{Stsy} = 1.33 \text{Ay} - 1.49 \text{PNSy} - 0.38 \). Two independent points defining for stomion superior were also found by Van Butsele et al\(^ {13} \); however, this pertained to their study for I-point and A-point and not for the posterior nasal spine. In our study, posterior nasal spine had a negative correlation coefficient, therefore dorsal impaction might have produced lip shortening. As the \( r^2 \) was 0.66, this equation might have indicated a strong relation between A-point and posterior nasal spine, on the one hand, and stomion superior on the other.

In the literature, different ratio coefficients for stomion superior were found. Mansour et al\(^ {15} \) found a statistically significant ratio coefficient of 0.54 between stomion superior and the vertical movement of A-point. Rosen\(^ {6} \) found a ratio of 0.32 between I-point and stomion superior and an \( r^2 \) of 0.46. Radney end Jacobs\(^ {14} \) found a statistically significant ratio of 0.26. The \( r^2 \) value was 0.77.

They also found that the vertical reduction of the distance between labrale superior and stomion was contingent upon the vertical movement of the posterior nasal spine with ratio coefficient 0.39 and A-point with ratio coefficient 0.12. This will result in vertical reduction of the upper lip in impaction cases. This effect of maxillary impaction was statistically ascertained here, although it was seen clinically in many patients. Probably the variation was such that formulating regression equations appeared impossible. As Schendel and Williamson\(^ {9} \) have pointed out, there is much variation between the independent and dependent points. A way to describe the relation between bony and soft tissue points more precisely would be to include more than 1 bony point in the equation. The \( r^2 \) would then probably have a greater value, as was the case in most of our combined equations (Table 3).

Horizontal movements of stomion were defined by the equation \( \text{Stsx} = 0.80 \text{Ix} + 0.89 \). Despite a forward movement of 0.2 mm and a standard deviation of 1.1, this statistically significant equation could be formulated. The ratio coefficient was much higher than what other authors found. Stella et al\(^ {16} \) could not find a ratio between the amount of forward movement of the maxilla and the forward movement of stomion superior. Van Butsele et al\(^ {13} \) found that stomion superior moved upward 30% of the horizontal movement of I-point. The same ratio was found by Dann et al\(^ {17} \) who found a ratio coefficient of 0.55 between I-point and labrale superior. Despite the high ratio coefficient of 0.80 found in this impaction group, it was evident that the upper lip would become thinner. The ratio coefficient was much higher compared to the results found in the literature, probably because of the very small forward movement of I-point.

As the ratio coefficient for horizontal movements was 0.80, some lip shortening as described earlier along with thinning of the lip was predicted to be likely. A V-Y plasty seemed insufficient; therefore, forward movement of the soft tissues of the lip with a cinch suture in combination with a V-Y plasty as described by Schendel and Williamson\(^ {9} \) proved to be a better option in these cases. As there were no statistically significant effects on the nose, any conclusion concerning reduction of the anterior nasal spine cannot be made here.

**Advancement.** Movements of the maxilla in different directions resulted in different equations with different bony points as independent variables. There were, however, some visible trends. Most statistically significant changes in a vertical or horizontal direction of the soft tissues of the nose were caused by horizontal movements of A-point and I-point. The equations for vertical soft tissue changes of the nose in advancement cases had negative ratio coefficients with horizontal movements of I-point (Table 3). This meant an increase of tip projection in advancement cases. The cinch suture prevented widening of the nose, but also increased tip projection.\(^ {7} \) With respect to the tip of the nose, a cinch suture would not be advantageous. For the increase of the maximal alar width, no statistically
significant equation was found; however, the alar cinch suture might have prevented excessive widening of the nose in individual cases.  

A ratio between the horizontal movement of I-point and labrale superior was found with an $r^2$ of 0.82. This equation, $L_{sx} = 0.65I_x - 0.06$, has a ratio coefficient that is less than the coefficient found by Mansour et al, who found a coefficient of 0.82 using A-point as an independent variable. Dann et al, however, found a ratio coefficient of 0.5 between horizontal movements of I-point and labrale superior. Freihofer found a ratio of 5:9 (0.5) between I-point and labrale superior. The volume of the upper lip was of importance, since thin lips follow the bony points better.

Vertical movement of stomion after forward movement of the maxilla was described by Van Butsele et al. It was found that the upper lip moved upward 30% of the amount of the advancement. The same ratio was found in the present study, where we obtained a correlation of $-0.33$ when using I-point as independent variable, which meant 33% upward movement.

Maxillary advancement surgery had more influence on the nose than on the lip. The soft tissues of the nose turned upward and moved forward. The effect on the lip was limited to an upward movement of stomion of about 33% of the forward movement. The lip became thinner after the maxilla moved forward, as the ratio coefficient between $L_{sx}$ and $I_x$ was 0.65. The effect on the nose became more pronounced; hence, we used a V-Y plasty only if the nose had a normal shape and position and refrained from using a cinch suture, as the cinch suture would have led to an increase of the nasolabial angle, as found by Westermark et al. If the nose needed an upward and forward movement, the V-Y plasty could have been combined with a cinch suture in order to prevent lip shortening and thinning. To prevent excessive tip rise, the anterior nasal spine would then have been removed.

Impaction and advancement. Combined movements of the maxilla gave equations with 2 independent points (Table 3). As to the 5 equations mentioned in Table 3, it is interesting to compare the equations defining $L_{sx}$ with $St_{sx}$ and to compare the equation for $L_{sy}$ with $St_{sy}$. Looking at the equations for $St_{sx}$ and $L_{sx}$, it is evident that the equation contains positive values only. $PNS_y$, however, has a negative value in upward movements. Combined with a positive ratio coefficient of 0.31, this will still result in a negative value. So $L_{sy}$ and $St_{sy}$ move upward. The other ratio coefficients of both formulas are in the same magnitude, but because of the influence of $PNS_y$, $St_{sx}$ will move forward to a lesser degree than $L_{sx}$. Thus, there will be some loss of lip projection, especially if there is more impaction than advancement.

Comparing $L_{sy}$ with $St_{sy}$, a different situation presents itself. $St_{sy}$ will have negative values as the coefficient $-0.27$ combined with $Ix$ will stay negative. $I_y$ will also have a negative value: When combined with a positive ratio coefficient, this will stay negative. This means stomion moves upward. The same is found for the equation defining for $L_{sy}$. Hence the lip as a whole will shorten, but its shape will stay intact. A V-Y plasty alone seems insufficient to prevent the loss of lip projection and lip shortening, and should therefore be combined with a cinch suture. There were no statistically significant equations describing the effects on the nose, except for subnasale. Hence any conclusive advice concerning additional soft tissue procedures to reduce the effects on the nose in combined impaction advancement cases cannot be made here.

Dorsal impaction. In the literature, no difference has been made between impaction and dorsal impaction. Normally, these groups are lumped together. Therefore, comparison with former results is not possible. If the equations of the dorsal impaction are compared with results found in the impaction group, it seems that there are differences to note between these 2 groups. In the dorsal impaction group, more equations could be formulated—some even with higher $r^2$ values, whereas in the impaction group only 2 equations concerning the lip could be defined, although both groups had comparable numbers of patients. The standard deviation for the impaction group was 1.1, whereas in the dorsal impaction group the...
SD was 3.0. Thus, the impaction group seemed to have been better selected than the dorsal impaction group. However, most statistically significant equations were found in the dorsal impaction group—some with high $r^2$ values.

The equations for Stsx had a different ratio coefficient. The ratio coefficient of the dorsal impaction was 0.47, which was less than the impaction group, where the ratio coefficient was 0.80. The same was true for Stsy, where we found a multiple regression equation for the impaction group and a linear equation for the dorsal impaction group, both, however, with a high $r^2$ value. The ratio coefficient between Stsy and Ay for the dorsal impaction group had a high value of 1.12. Differences in soft tissue behavior, therefore, exist between dorsal impaction and pure impaction of the maxilla.

All the soft tissue structures in cases of dorsal impaction were dependent upon A-point. The I-point and posterior nasal spine did not seem to play any role. High ratios were found for vertical movements of A-point and Stsy, Lsy, Sny, and Pny, with the highest $r^2$ values (Table 3, last part). The horizontal movements of the soft tissues had smaller ratios; therefore, in cases of dorsal impaction, the final position of A-point was important for the prediction of the profile. The ratio coefficients for the horizontal movements of the upper lip were twice as small as the ratio coefficients of the vertical movements of the upper lip. If the forward movement of A-point is twice as big as the upward movement, the change of the shape of the upper lip might be minimal, and lip projection might be kept normal. But if the amount of upward movement is more than the forward movement of A-point, this will result in shortening of upper lip and loss of horizontal lip projection.

There will be thinning of the lip anyhow, as the ratio coefficient for the horizontal movements of Lsx and Stsx was 0.47. In our estimation, every dorsal impaction case should be combined with a cinch suture in order to prevent flattening of the lip. The horizontal movement of A-point should be twice as big as the vertical movement of A-point, if at all possible. The effects on the nose are mainly dependent upon the movement of A-point $Pnx = 0.46Ax - 067$, and $Pny = 1.03Ay + 0.53$. The most anterior point of the nose will move forward and upward. Excessive upward rotation can be prevented by removing the anterior nasal spine and grinding the paranasal area. If an obtuse labial angle exists preoperatively, it might be better to refrain from an alar base cinch suture.

As a general conclusion concerning this particular study we might state that a V-Y plasty alone is not sufficient for most directions of movement to prevent changes of lip and nose. Although consistent results will be difficult to obtain due to great patient variation, it remains to be studied in a prospective way which other soft tissue procedures are best suited to being combined with a Le Fort I osteotomy.

References


