Impact of dental and skeletal movements on the facial profile within the framework of orthodontic and surgical treatments

The impact of dental and skeletal movements on the soft tissues during orthodontic and surgical treatments is widely known. Most studies are limited to examining the repercussions of a dental or skeletal movement on a given soft tissue point. The uniqueness of the present study, carried out on 95 patients, lies in the examination of the impact of movements of various landmarks—2 dental points (incision superius and incision inferius) and 4 skeletal points (anterior nasal spine, point A, point B, and pogonion)—on 7 soft tissue landmarks (from the tip of the nose to soft tissue pogonion). The study was carried out with the purpose of providing a simple, practical, and accurate tool for clinical use to assist in treatment planning. This article outlines the main aspects of the tool while specifying its limitations and error margins.


Many studies have already been undertaken to determine the repercussions of tooth and skeletal movements occurring during orthodontic and surgical treatments on the soft tissues of the face. Dodocky and Smith\(^1\) studied the impact of the extraction of the first 4 premolar teeth as part of orthodontic treatment on 160 patients. They observed that the upper lip and lower lip retracted (3.4 mm and 3.6 mm, respectively) in relation to the Ricketts line. They also noted an increase in the nasolabial angle as well as in the angle formed by the lip and chin (5.2 degrees and 2 degrees, respectively). The same observations were made by Bravo\(^2\): the upper lip retracted by 3.4 mm in relation to the Ricketts line and the lower lip by 3.8 mm, while the nasolabial angle increased by 3.7 degrees and the lip-chin angle increased by 0.1 degrees.

Young and Smith\(^3\) and Katsaros et al\(^4\) furthermore observed that when incision superius (Is) retracts by 7 mm and incision inferius (Ii) retracts by 5.5 mm, this causes a retraction of the upper lip by 2 mm and the lower lip by 3.2 mm. They explained that the smaller retraction of the upper lip in relation to the lower lip is the result of a reduction in labial tension, which causes the lip to thicken. Garcia and Guedon\(^5\) analyzed the effects of a surgically assisted expansion of the mandible and noted a 75% expansion of the lower lip in relation to the skeletal expansion.

Computer simulations have also been performed to examine soft tissue movements following hard tissue movements. Denis and Spledel\(^6\) compared 3 data analysis methods aimed at anticipating soft tissue movements. They concluded that the most reliable method was to manually
enter the numeric data corresponding to the various cephalometric points; these data are then processed by means of equations drawn from tables of averages. The computer program then discriminated between the specific characteristics of the initial soft and hard tissues. Lew undertook a study of computer-processed cephalometric predictions on surgical corrections of bimaxillary protrusion. On one hand, he noted that the predictions were more reliable than with manually drawn simulations. On the other hand, he noted frequent errors in relation to the results obtained in reality.

Most studies are aimed exclusively at examining the movements of the maxillary and mandibular incisors and their impact at the labial level. Authors generally group their patient samples by type of treatment, i.e., the impact of retraction of the maxillary central incisors on the upper lip following extraction of the first 4 premolars. The results published are laid out in the form of averages expressed in millimeters or degrees, or as the relationship between the movement of soft tissues and hard tissues.

The originality of the present study lies in the fact that it examines the movements of 6 dental and skeletal landmarks and the impact of these movements on 7 soft tissue landmarks. Our study is based on the assumption that there are a number of interactions linking the various dental and skeletal movements and that these can have an impact on the corresponding soft tissues.

Methods

The sample group that took part in the study consisted of 95 patients who had received orthodontic treatment or a treatment combining orthodontics and orthognathic surgery. The treatments were performed by the postgraduate team of the Dental and Facial Orthopedics Department of Hôpital Universitaire Erasme in Brussels, with the assistance of a specialist in maxillofacial surgery belonging to the same hospital. The patients were selected on the basis of the quality of their pre- and post-therapeutic profile radiographs. The sample group was made up of 67 female patients and 28 male patients aged between 7 and 37 years (average age 18) who had previously undergone standard orthodontic treatment based on the edgewise technique, orthopedic treatment, surgical maxillary movement, surgical mandibular movement, or surgical bimaxillary movement.

Measurements

All cephalometric outlines were executed by the same person, following a customized measurement protocol. Two dental points (Is and Ii); 4 skeletal points (anterior nasal spine [ANS], point A [A], point B [B], and pogonion [Pog]); and 7 soft tissue points (pronasale [Pn], soft tissue point A [A’], labrale superius [Ls], stomion [St], labrale inferius [Li], soft tissue point B [B’], and soft tissue pogonion [Pog’]) were chosen for the purpose of pre- and posttreatment cephalometric comparison (Fig 1). Two orthogonal axes—the De Coster line as the horizontal axis and a perpendicular to this line going through sella as the vertical axis—were chosen as the referential axes. A millimetric grid parallel to the 2 axes was used to measure the horizontal and vertical movements of the various points that were the object of the present study.

Fig 1  Skeletal, dental, and soft tissue landmarks whose movements were studied according to the 2 orthogonal axes. A = point A; A’ = soft tissue point A (point of maximum concavity of the upper lip); ANS = anterior nasal spine; B = point B; B’ = soft tissue point B (point of maximum concavity of the lower lip); Is = incision superius; li = incision inferius; Li = labrale inferius; Ls = labrale superius; Pn = pronasale; Pog = pogonion; Pog’ = soft tissue pogonion; St = stomion.
**Statistical methods**

We calculated the means, the standard deviations, and the coefficients of variation of 20 measurements performed on each point of the same radiograph to quantify the reproducibility of the measurements (Table 1). We then performed a step-by-step linear regression of both the horizontal and vertical components of the movement of each soft tissue point, including as independent variables the components corresponding to the movements of dental or skeletal landmark, to identify the components of dental or skeletal movements that influenced the soft tissues most significantly. The statistical calculations required for this procedure were performed with SPSS 10.0 software. Finally, we calculated the displacement ratios of each soft tissue point in relation to the displacement of their corresponding hard tissues. The average values of these ratios are featured in Table 2.

**Results**

The linear regression highlighted the dental or skeletal points whose movements are most likely to have an impact on each one of the soft tissue landmarks under examination (Table 3). For each soft tissue point, the interval between the corresponding dental or skeletal points delimits a segment of hard tissue. In clinical
terms, it is this segment of hard tissue that has an effect on the soft tissue point under examination. Indeed, each time a dental or skeletal point moves, an entire structure actually is moved. For example, the protraction of point Is corresponds to a protraction of the entire maxillary incisor and its alveoli, defining a segment of hard tissue. These segments, as well as their corresponding soft tissue points, are featured in Figs 2a to 2c.

The average displacement ratios of the soft tissue in relation to the displacement of the corresponding hard tissue can, for their part, be used in actual practice as a means to predict soft tissue movements (Table 2).

**Discussion**

Most of the observations made as part of this study follow a self-explanatory clinical logic. For example, when Pog moves...
forward, Pog’ also moves forward. However, in some cases, further insight is required.

The movement of the maxillary incisors has a more pronounced effect on the lips and St than does the movement of the mandibular incisors. In all likelihood, this must be a result of the overlap of the maxillary incisors on the mandibular incisors in the sagittal direction. This leads us to conclude that the soft tissues, including the lower lip, rest mainly on Is.

When the incisors retract, the lips also retract. However, the retraction observed at the labial level is less dramatic than the incisor retraction. This may be the result of a decrease in labial tension, which leads to a slight increase in labial volume. The same conclusions can be drawn for A’ and B’ and their corresponding hard tissues. Likewise, when the hard tissues move forward, the corresponding soft tissues move but to a proportionally lesser extent. This may be due to an increase in soft tissue tension, resulting in reduced soft tissue thickness.

The vertical movements of B induce horizontal movements of Pog’. This may be a result of the fact that movements of B are often related to an anterior or posterior mandibular rotation, which proceed within the 2 spatial planes.

The proportions that have not been included in Table 2 are considered statistically insignificant.

A number of considerations must be pointed out regarding the influences and obstacles encountered during the course of our study. Our work is aimed at analyzing dental and skeletal movements and their impact on soft tissue landmarks, irrespective of the treatment. We consider the therapeutic techniques used purely as the...
means to induce dental or skeletal movement. It is, in effect, the resulting movement—not the means used to provoke it—that draws our attention. We were faced with a number of constraints. The small number of cases registered, the countless interactions between movements which, for practical reasons, had to be studied separately from one another, not to mention the condensing of 3-dimensional movements into 2 spatial planes. All of these factors can lead to inaccurate results. The thickness and muscular tone of the soft tissues prior to treatment can influence their modifications. Growth and aging likewise alter the positioning of the soft tissues. Such modifications have little or no impact on short-term treatment but are likely to have an influence on longer-term treatments, or in treatments involving a succession of different prostheses, for example, a removable orthopedic treatment device followed by fixed orthodontic treatment. The modifications undergone by the soft tissue as a result of growth, aging, and changes in muscular tone have not been taken into consideration for the purpose of this study.

Finally, certain surgical manipulations or factors related to the scarring of soft tissue following surgical operations can also influence the results obtained. To limit the error factor as much as possible, we made sure that all the patients included in our study were treated by the same surgeon.

**Conclusion**

The drawing up of an orthodontic treatment plan implies that the practitioner should be able to take into account a number of priorities, most significantly the restoration of a correct occlusion and facial harmony. The restoration of a correct occlusion often goes hand in hand with improved facial harmony. Nonetheless, it should be pointed out that in some cases, facial harmony may be upset as a result of restoring the occlusal balance. Class II, division 2 cases are an example of this. These can be treated either by means of fixed orthodontic treatment combined with the extraction of 2 maxillary premolars, or through dental correction and surgically assisted mandibular expansion. This means that whenever there are various therapeutic alternatives to choose from, provided all these options are acceptable from an occlusal point of view, the patient’s choice may be guided on the basis of the results that each of the proposed solutions would have on the patient’s facial harmony. Finally, it may be useful to predict the persistence of “unwanted” elements in the facial harmony even after the performance of orthodontic or surgical treatment. Therefore, complementary alternative solutions could be proposed to the patient, including cosmetic surgery (e.g., rhinoplasty).

A comparison of the results in relation to the aims shows that statistical regression has effectively enabled us to identify a number of skeletal and dental surfaces that affect each point of the soft tissue under examination. The calculation of the displacement ratios of the soft tissue in relation to the corresponding hard tissue, on the other hand, has allowed us to quantify these movements and to give them a direction in space. Finally, as regards these ratios, the calculation of the standard errors, featured in Table 2, shows that the margin of error in relation to the results actually reached varies depending on the point in question. The practitioner will have to take this into consideration upon drawing up a treatment plan or in the event of any “esthetic promises” made to the patient.

**References**


