applied sciences

MDPI

Article

Soft Tissue Movement in Orthognathic Surgery: Does Pre-Operative Soft Tissue Thickness Affect Movement Change?

Michael V. Joachim [1,2,*], Yair Brosh [1], Fadi Daoud [3], Murad Abdelraziq [1], Imad Abu El-Naaj [1,2] and Amir Laviv [4]

[1] Department of Oral and Maxillofacial Surgery, Baruch Padeh Medical Center, Poriya 1520800, Israel
[2] Azrieli Faculty of Medicine, Bar-Ilan University, Safed 5290002, Israel
[3] Maurice and Gabriela Goldschleger School of Dentistry, Sackler Faculty of Medicine, Tel Aviv University, Tel Aviv 6997801, Israel
[4] Department of Oral and Maxillofacial Surgery, Maurice and Gabriela Goldschleger School of Dentistry, Sackler Faculty of Medicine, Tel Aviv University, Tel Aviv 6997801, Israel
* Correspondence: michael.joachim@biu.ac.il; Tel.: +972-4-6652254

Abstract: Background: The aim of this study was to examine whether the thickness of the preoperative soft tissue affects the degree of soft tissue movement relative to the hard tissue movement after orthognathic surgery. Methods: This is a retrospective examination of lateral cephalometric X-rays of patients who underwent orthognathic surgery in single medical center, during a 5-year period. Demographic and operative data were collected. Soft tissue thickness was measured in preoperative cephalometric X-ray, followed by superimposition of postoperative (>6 months) cephalometric X-rays by overlapping fixed bony points. Results: In the upper jaw, there was a decrease in the relative movement of soft tissue with an increase in the initial thickness in surgeries performing advancements up to 5 mm (r = −0.288). In mandibular advancements, there was a clear decrease in soft tissue movement ratio with an increase in the initial soft tissue thickness (r = −0.418), while there was no correlation in mandibular setback cases (r = 0.062). The same correlation between the decrease in relative soft tissue movement and the increase in initial soft tissue thickness was found in advancement genioplasty (r = −0.411). Conclusion: This research shows a general pattern of decrease in relative movement of soft tissue in orthognathic surgery correlated to an increase in its initial thickness.

Keywords: orthognathic surgery; soft tissue movement; surgery prediction; surgery tracing

check for updates

Citation: Joachim, M.V.; Brosh, Y.; Daoud, F.; Abdelraziq, M.; Abu El-Naaj, I.; Laviv, A. Soft Tissue Movement in Orthognathic Surgery: Does Pre-Operative Soft Tissue Thickness Affect Movement Change? *Appl. Sci.* **2022**, *12*, 8170. https://doi.org/10.3390/app12168170

Academic Editor: Andrea Scribante

Received: 30 June 2022
Accepted: 13 August 2022
Published: 16 August 2022

Publisher's Note: MDPI stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Copyright: © 2022 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (https://creativecommons.org/licenses/by/4.0/).

1. Introduction

Orthognathic surgery is a jaw correction surgery, widely performed for correction of congenital and acquired facial deformities. This surgery improves the masticatory function of the dentition, as well as facial harmony and aesthetics. Surgical hard tissue (HT) movement in this surgery is followed by soft tissue (ST) movement and different attempts were performed to assess the association between the changes in soft and hard tissue after orthognathic surgery [1–4].

Accurate assessment of hard and soft tissue changes is an essential part of diagnosis and treatment planning in orthognathic surgery. It is mainly important for the matching between patient's pre-surgical expectations and the reality of surgical possibilities and outcomes [5].

Previous studies found association between preoperative ST thickness and the post-operative changes due to HT movement [2,6–8]. It was found that the structure of facial ST and facial profile are dependent on the underlying bone, but the bone change is not expressed equally in each ST area [6]. For example, it was found that upper lip movement is 60–90% of HT movement [7], while in the lower lip the rate is 90–100% and in the chin it is 55–90% [2,8,9].

Moreover, there are reports that claim that because of ST thickness differences between patients, the assumptions of constant relative movements are inaccurate [10]. There is an

influence of the pre-surgical ST thickness on its relative movement and it affects pre-surgical planning and outcome prediction [11,12].

Prediction of ST changes is completed by two-dimensional cephalometric evaluation, performed pre- and post-surgery [13]. This evaluation may be performed manually or digitally, using various digital software options, sometimes combined with video shots. Additionally, there are three-dimensional prediction methods [13].

Manual prediction is based on expected changes [14], while digital software programs are based on average values from databases, reported in previous studies that measured the relationship between soft and hard tissue movement, both giving limited and inaccurate estimates of predicted ST movement [15,16]. As a consequence, the accuracy of the simulations is based on the reliability and accuracy of the database used [1].

All manual and most digital methods assume that ST response is linear to HT movement, regardless the preoperative amount and movement direction of the skeletal tissue [1,14]. The validity of this assumption is not only debatable, but also inconsistent in different reports from various studies [10].

Additionally, previous reviews showed that differences in measuring and prediction methods, it was impossible to achieve significant conclusions regarding ST movement in this surgery [17].

The great variability and lack of agreed measuring standard complicate accurate assessment of post-surgical ST outcome, as well as the influence of pre-surgical ST thickness on its movement ratio.

The aim of this study was to examine whether the thickness of the preoperative ST affects the degree of ST movement relative to the HT movement after orthognathic surgery. Null hypothesis was that there is an influence of initial ST thickness on its relative movement after orthognathic surgery.

2. Materials and Methods

2.1. Definition of Study Sample

All patients who underwent an orthognathic surgery in the department of oral and maxillofacial surgery at the Baruch Padeh medical center, Poriya, Israel between September 2013 and September 2018. In total, 42 patients met inclusion criteria with full patient and surgery data and were included in the study. As it was a retrospective study, based on availability of full patient data, no sample size calculations were performed.

Exclusion criteria: asymmetry cases—need for fixing differences in size or position of face halves, redo surgery cases, and unavailable X-rays.

2.2. Definition of Variables

Dependent variable: post-operative movement of soft tissue in millimeters (mm) in relation to operative hard tissue movement in millimeters.

Independent variable: preoperative thickness of soft tissue in millimeters.

2.3. Research Methods

The current study is a retrospective study. According to treatment protocol in OMFS at Baruch Padeh MC, every orthognathic patient gets a lateral cephalometric X-ray at most 1 month prior to surgery, another one in the first 48 h postoperative and another one 6 months postoperative. All x-rays were performed by the same X-ray machine.

The analysis was divided into three categories: surgeries involving the maxilla, surgeries involving the mandible, and surgeries involving the chin. We checked only horizontal movement and checked it regardless of surgery type performed—as a methodological assumption—in order to get larger study groups and allow us to obtain individual independent and dependent variables.

All measurements were performed by the same researcher (F.D.) on those lateral cephalometric X-Rays, using measuring tools (on screen digitization) of Dolphin Ceph Tracing 11.95 (Dolphin Imaging & Management Solutions, Chatsworth, CA, USA). The

software enables measuring the accurate distance between two points on an image in millimeters after calibration with "on image" ruler.

The following data were collected for all study participants: age, sex, medical condition, operated jaw/area, and operational movement (advancement, setback). Figure 1 shows the measurements conducted for all patients: upper lip thickness (A-A'), lower lip thickness (B-B'), and chin ST thickness (Pog-Pog').

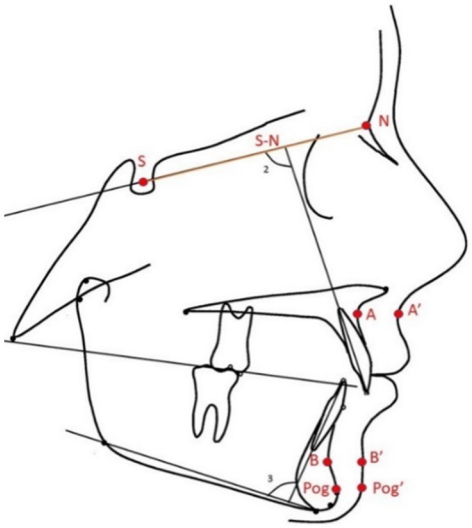


Figure 1. Lateral cephalometric X-ray measuring points. Abbreviations: S—Sella Turcica, N—Nasion, A—Hard tissue A point, A'—Soft tissue A point, B—Hard tissue B point, B'—Soft tissue B point, Pog—Hard tissue pogonion, and Pog'—Soft tissue pogonion.

The measurements of hard and soft tissue operational changes were performed by superimposition of preoperative and 6 months postoperative lateral cephalometric X-Rays. The superimposition was performed by aligning constant hard tissue points (not affected by surgery)—Nasion (N), Sella Turcica (S), and S-N line.

Changes of hard tissue were measured by the following points:

- Patients after maxillary surgery—A postop-A preop distance;
- Patients after mandibular surgery—B postop-B preop distance;
- Patients after chin surgery—Pog postop-Pog preop distance;
- Soft tissue Changes were measured in the same way: A' postop–A' preop distance; B' postop–B' preop distance; and Pog' postop–Pog' preop distance;
- Preoperative soft tissue thickness was measured on preoperative X-ray (A-A', B-B', Pog-Pog'—Figure 1).

All measurements were made independently of the surgery type performed and were taken for every area that was intentionally horizontally moved during surgery.

The relation between postoperative hard and soft tissue movement was calculated by division of soft tissue movement to relevant hard tissue movement—$\frac{X'_{postop} - X'_{preop}}{X_{postop} - X_{postop}}$ (X = A/B/Pog).

2.4. Statistical Analysis

Statistical analysis was performed using Excel (2021 version, Microsoft, Redmond, WA, USA) and Prism (9.0 version, Graphpad, San Diego, CA, USA) software for MS Windows. Comparisons between subgroups were made using the *t*-test, Fisher's exact test, and chi-square test. Adjustment factors were calculated by the Pearson method. Linear regression was tested for correlation between variables and outcomes. Comparison of correlation from independent samples was calculated by Eid, Gollwitzer, and Schmidt method. A probability <0.05 was considered significant.

3. Results

This study included 42 patients with complete available data, including pre- and post-surgical imaging and full data about the surgical movements. Mean age in this study was 21.8 ± 6.9 years (range 16–32), with 27 female patients (64.3%) and 15 males (35.7%). Preoperative ST measurements are presented in Table 1. Surgical HT movement measurements are presented in Table 2.

Table 1. Preoperative soft tissue measurements.

	N	Mean (+SD)	*p* Value (*t*-Test)
Preoperative soft tissue thickness upper lip (A-A'—mm)	33	13.79 + 2.37	
Preoperative soft tissue thickness upper lip—<5 mm advancement (A-A'—mm)	16	14.06 + 2.77	0.53
Preoperative soft tissue thickness upper lip—>5 mm advancement (A-A'—mm)	17	13.53 + 1.97	
Preoperative soft tissue thickness lower lip (B-B'—mm)	35	11.23 + 1.6	
Preoperative soft tissue thickness lower lip—setback cases (B-B'—mm)	21	11.75 + 1.46	0.006
Preoperative soft tissue thickness lower lip—advancement cases (B-B'—mm)	14	10.28 + 1.46	
Preoperative soft tissue thickness upper lip (Pog-Pog'—mm)	6	11.8 + 2.44	

Table 2. Surgical hard tissue movement measurements.

	Mean (+SD)
Maxillary AP advancement (N = 33, mm)	5.55 + 2.12
Mandibular AP advancement (N = 14 mm)	5.96 + 2.42
Mandibular AP setback (N = 21 mm)	−6.21 + 2.52
Chin AP advancement (N = 6 mm)	6.02 + 3.2

The most prevalent type of surgery was bi-jaw surgery, performed in 57.1% of the cases, followed by mandible only surgery in 16.7% of the cases (Table 3).

Table 3. Prevalence of different surgery types.

Type	Count	%
Bi-Maxillary (Two Jaws)	24	57.1%
Bi-Maxillary and chin	4	9.5%
Maxilla only	5	11.9%
Maxilla and chin	1	2.4%
Mandible only	7	16.7%
Mandible and chin	1	2.4%
Total	42	100.0%

In 33 of the cases involved advancement of the maxilla. The mean preoperative ST thickness (A-A') was 13.79 ± 2.37 mm (range 9–18.9). Mean surgical HT advancement was 5.55 ± 2.12 mm (range 1.6–9.1). Analyzing the linear regression of the correlation between preoperative ST thickness and the relation between hard and soft tissue postoperative movement in maxillary advancement cases, there was no significant correlation ($r = -0.101$, $p = 0.58$), but the general trend points on decrease in relative ST movement with the increase in its initial thickness. Same analysis in cases of less than 5 mm maxillary advancement (16 cases), revealed a clear trend, albeit not statistically significant, of decrease in relative movement of postoperative ST with the increase in its initial thickness ($r = -0.288$, $p = 0.28$, Figure 2). However, in cases of >5 mm maxillary advancement (17 cases), there was a trend, albeit not statistically significant, of increase in relative ST movement with the increase in its preoperative thickness ($r = 0.308$, $p = 0.22$, Figure 3). There was no statistically significant difference between pre-surgical ST thickness between the two groups ($p = 0.53$, Table 1).

Comparison on ST/HT movement ratio between >5 mm and <5 mm maxillary advancement revealed not statistically significant difference between the groups (0.906 ± 0.297 vs. 0.928 ± 0.185, p = 0.797, t-test).

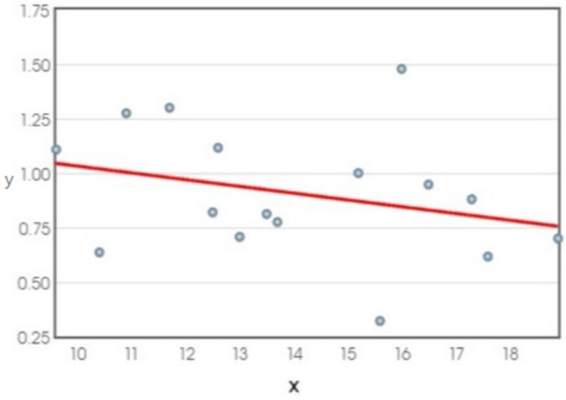


Figure 2. Correlation between initial ST thickness in the maxilla (x axis) and the relation between postoperative soft and hard tissue movement (y axis)—cases of maxillary advancement of 5 mm or less (N = 16, p = 0.28).

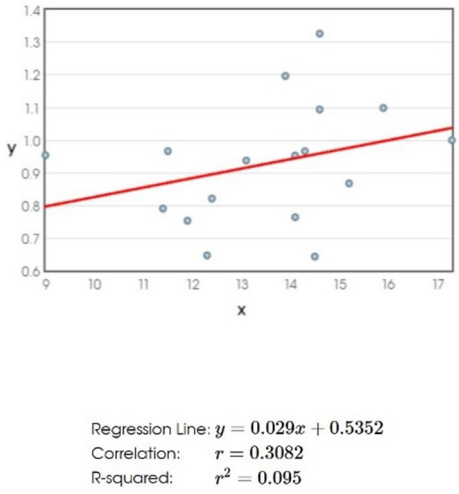
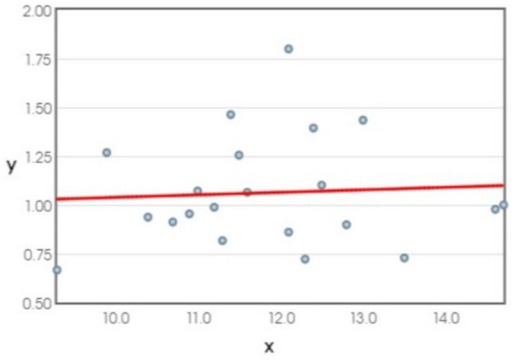


Figure 3. Correlation between initial soft tissue thickness in the maxilla (x axis) and the relation between postoperative soft and hard tissue movement (y axis)—maxillary advancement of more than 5 mm (N = 17, p = 0.23).

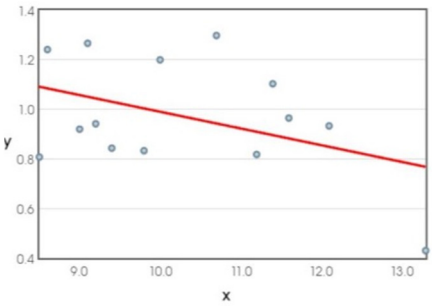
In total, 35 of the cases involved horizontal movement of the mandible. The mean preoperative ST thickness (B-B') was 11.23 ± 1.6 mm. Analyzing the linear regression of the correlation between preoperative ST thickness and the relation between hard and ST postoperative movement in mandibular horizontal movement cases, there was no correlation or trend (r = −0.011, p = 0.95). We stratified the analysis to check advancement and setback movements separately. There was a statistically significant difference in pre-surgical tissue thickness between the groups (p = 0.006), with the setback group having initially thicker ST. In setback cases (21 cases—mean surgical HT movement −6.21 ± 2.52 mm) there was no significant trend to point on (r = 0.06, p = 0.79, Figure 4). However, in mandibular

advancement (14 cases—mean surgical HT movement 5.96 ± 2.42 mm), there was a clear and borderline significant trend of decrease in relative ST movement with the increase in its preoperative thickness (r = −0.417, p = 0.12, Figure 5).



Regression Line: $y = 0.0129x + 0.9103$
Correlation: $r = 0.0625$
R-squared: $r^2 = 0.0039$

Figure 4. Correlation between initial soft tissue thickness in the maxilla (x axis) and the relation between postoperative soft and hard tissue movement (y axis)—cases of maxillary advancement of 5 mm or less (N = 16, p = 0.28). Correlation between initial soft tissue thickness in the mandible (x axis) and the relation between postoperative soft and hard tissue movement (y axis)—mandibular setback cases (N = 21, p = 0.79).



Regression Line: $y = -0.0673x + 1.6638$
Correlation: $r = -0.4178$
R-squared: $r^2 = 0.1746$

Figure 5. Correlation between initial soft tissue thickness in the mandible (x axis) and the relation between postoperative soft and hard tissue movement (y axis)—mandibular advancement cases (N = 14, p = 0.12).

Six of the cases involved horizontal advancement of the chin. The mean preoperational ST thickness (Pog-Pog') was 11.8 ± 2.44 mm. Mean surgical HT advancement was 6.02 ± 3.2 mm. Analyzing the linear regression of the correlation between preoperative ST thickness and the relation between hard and soft tissue postoperative movement in chin advancement cases, there was a clear, albeit not statistically significant, trend of decrease in relative ST movement with the increase in its preoperative thickness (r = −0.411, p = 0.42).

4. Discussion

In the current research, we retrospectively analyzed cephalometric X-rays of orthognathic surgery patients in order to check the preoperative thickness of their ST and the

amount of its movement in different types of surgeries involving the maxilla, mandible, and the chin. The research was performed to check whether preoperative ST thickness affects the relative degree of ST movement in orthognathic surgery.

The analysis was divided into three categories: surgeries involving the maxilla, surgeries involving the mandible, and surgeries involving the chin.

In the maxilla (33 cases), in was revealed that overall trend pointed on decrease in relative ST movement with the increase in its initial thickness ($r = -0.101$). Though, dividing the cases to those involving 5 mm or less advancement (16 cases) and more than 5 mm advancement (17 cases), revealed that in $\leq$5 mm there was clear trend of decrease in relative ST movement with the increase in its initial thickness ($r = -0.2882$), while in >5 mm cases the trend was quite the opposite ($r = 0.3082$). Same stratification was performed in previous report, showing that in >5 mm maxillary advancement, it is more difficult to predict ST relative movement [18].

A possible explanation for the decrease in relative ST movement with the increase in its initial thickness may be related to the fact that thick ST absorbs part of the operative changes to the HT [18]. Moreover, several previous reports showed that higher initial ST thickness causes its relatively smaller movement in correlation to HT movement [7,18,19].

The unusual finding was in >5 mm maxillary advancements, with a clear trend of increase in relative ST movement with the increase in its initial thickness and the explanation for this may be that the ST, even a thick one, cannot absorb relatively large movement (>5 mm). Previous reports in similar movements showed great difficulty in relative ST movement prediction and difficulty to achieve good correlation [7].

In surgeries involving the mandible (35 cases), there was no possibility to point a clear general trend because of the great difference between the characteristics of advancement and setback surgeries. Checking up separately setback (21 cases) and advancement (14 cases) surgeries, revealed that in advancement cases there is a clear trend of decrease in relative ST movement with the increase in its initial thickness ($r = -0.4178$), while setback cases did not show any clear trend ($r = -0.0625$). Regarding preoperative condition, setback cases have significantly thicker ST.

The trend of decrease in relative ST movement with the increase in its initial thickness may be explained identically as it was in small advancements of the maxilla with the absorption of HT movement by thick ST [18]. However, in setback cases it is not possible to point out any trend, in line with previous reports, showing very low regression coefficient of hard and ST movement in mandibular setback cases [15,20,21]. Same findings were presented in a systematic review on this subject [22]. The explanation primary relates to the surgical movement itself, as in advancement there is an anterior pulling of the tissue causing its stretching and the amount of the stretch depends on its ability to absorb the subsequent tension—an ability very much dictated by its initial thickness. On the other hand, in setback surgery, the ST does not move posteriorly univalent with the HT and thus the influence of initial ST thickness is less evident. This finding is exaggerated by the significant difference in initial tissue thickness between the groups, with setback patients having, on average, 1.5 mm more pre-surgical ST thickness than advancement patients.

In chin advancement surgeries (6 cases), there was a clear trend of decrease in relative ST movement with the increase in its initial thickness ($r = -0.4113$). Once again, it may be explained by absorption of HT movement by thick ST, as it was present previously in this study and in previous reports [19].

The limitations of this research:

- Some of the performed surgeries involved more than one jaw. This creates a situation in which we check similar movements in different surgeries that may affect the outcome—it is known that one jaw surgery might affect ST of the other. Further research in larger sample groups would require stratification not only along direction of movements or the jaw moving, but also the type of surgery and other movements along the one that is being checked.

- We had a relatively small study group (cases with insufficient data were excluded) causing difficulty in reaching statistically significant results. This resulted in dealing with trends in present cases without performing a calculation of study samples.
- There is a limitation in the ability to check the relation between hard and soft tissue movements in lateral cephalometric X-ray due to several factors: complex anatomical structures, superimposition of two images, image sharpness and quality, and the ability of the researcher to mark accurately the reference points.
- Selection bias—only fully documented cases were selected; it is not known whether other operated cases may have changed the results.

Therefore, there is a need for future multi-center, multi-national research with a large patient pool and the ability to isolate different types of surgeries allowing statistical analysis of every movement in every type of surgery, without methodological assumptions and clear connection between trends and surgical movements.

5. Conclusions

In this study, we showed a general trend pointing that the relative surgical movement of soft tissue is decreasing with the increase in its initial width. The only exception was in >5 mm maxillary advancement resulting in opposite results, possible because of the amount of movement in the surgery itself. There is a need for further research in bigger study samples, possibly prospective ones, in order to obtain more clear and significant results. Evaluation of these data may help in the future in the accuracy of presurgical planning and outcome prediction of orthognathic surgeries—enhancing better surgical outcomes, matching more closely patients' needs and expectations.

Author Contributions: Conceptualization, Y.B., A.L. and I.A.E.-N.; methodology, M.V.J. and A.L.; software, M.V.J.; validation, M.V.J. and M.A.; formal analysis, M.A. and A.L.; investigation, M.V.J. and F.D.; resources, I.A.E.-N. and A.L.; writing—original draft preparation, Y.B. and F.D.; writing—review and editing, M.V.J., M.A., I.A.E.-N. and A.L.; supervision, I.A.E.-N. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki, and approved by the Institutional Review Board of the Baruch Padeh Medical Center (protocol code POR-19-0109, date of approval: 5 February 2020).

Informed Consent Statement: Patient consent was waived by the Institutional Review Board of the Baruch Padeh Medical Center.

Data Availability Statement: Data are available by request from the corresponding author.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Chew, M.T.; Sandham, A.; Wong, H.B. Evaluation of the Linearity of Soft- to Hard-Tissue Movement after Orthognathic Surgery. *Am. J. Orthod. Dentofac. Orthop.* **2008**, *134*, 665–670. [CrossRef] [PubMed]
2. Olate, S.; Zaror, C.; Blythe, J.N.; Mommaerts, M.Y. A Systematic Review of Soft-to-Hard Tissue Ratios in Orthognathic Surgery. Part III: Double Jaw Surgery Procedures. *J. Cranio-Maxillofac. Surg.* **2016**, *44*, 1599–1606. [CrossRef] [PubMed]
3. Bailey, L.J.; Collie, F.M.; White, R.P.J. Long-Term Soft Tissue Changes after Orthognathic Surgery. *Int. J. Adult Orthodon. Orthognath. Surg.* **1996**, *11*, 7–18. [PubMed]
4. McFarlane, R.B.; Frydman, W.L.; McCabe, S.B.; Mamandras, A.M. Identification of Nasal Morphologic Features That Indicate Susceptibility to Nasal Tip Deflection with the LeFort I Osteotomy. *Am. J. Orthod. Dentofac. Orthop.* **1995**, *107*, 259–267. [CrossRef]
5. Miguel, J.A.M.; Palomares, N.B.; Feu, D. Life-Quality of Orthognathic Surgery Patients: The Search for an Integral Diagnosis. *Dent. Press J. Orthod* **2014**, *19*, 123–137. [CrossRef]
6. Subtelny, J.D. A Longitudinal Study of Soft Tissue Facial Structures and Their Profile Characteristics, Defined in Relation to Underlying Skeletal Structures. *Am. J. Orthod.* **1959**, *45*, 481–507. [CrossRef]
7. San Miguel Moragas, J.; Van Cauteren, W.; Mommaerts, M.Y. A Systematic Review on Soft-to-Hard Tissue Ratios in Orthognathic Surgery Part I: Maxillary Repositioning Osteotomy. *J. Cranio-Maxillofac. Surg.* **2014**, *42*, 1341–1351. [CrossRef]

8. San Miguel Moragas, J.; Oth, O.; Büttner, M.; Mommaerts, M.Y. A Systematic Review on Soft-to-Hard Tissue Ratios in Orthognathic Surgery Part II: Chin Procedures. *J. Cranio-Maxillofac. Surg.* **2015**, *43*, 1530–1540. [CrossRef]
9. Ohba, S.; Kohara, H.; Koga, T.; Kawasaki, T.; Miura, K.I.; Yoshida, N.; Asahina, I. Soft Tissue Changes after a Mandibular Osteotomy for Symmetric Skeletal Class III Malocclusion. *Odontology* **2017**, *105*, 375–381. [CrossRef]
10. Burstone, C.J. The Integumental Profile. *Am. J. Orthod.* **1958**, *44*, 1–25. [CrossRef]
11. Abeltins, A.; Jakobsone, G. Soft Tissue Thickness Changes after Correcting Class III Malocclusion with Bimaxillar Surgery. *Stomatologija* **2011**, *13*, 87–91. [PubMed]
12. Yeo, B.-Y.; Kim, J.-S.; Kim, J.; Kim, J.-Y.; Jang, W.-W.; Kang, Y.-G. Submandibular Soft Tissue Changes after Mandibular Set-Back Surgery in Skeletal Class III Patients. *J. Stomatol. Oral Maxillofac. Surg.* **2019**, *120*, 301–309. [CrossRef] [PubMed]
13. Kolokitha, O.-E.; Topouzelis, N. Cephalometric Methods of Prediction in Orthognathic Surgery. *J. Maxillofac. Oral Surg.* **2011**, *10*, 236–245. [CrossRef] [PubMed]
14. Wolford, L.M.; Hilliard, F.W.; Dugan, D.J. *Surgical Treatment Objective: A Systematic Approach to the Prediction Tracing*; CV Mosby: Maryland Heights, MO, USA, 1985.
15. Kolokitha, O.E.; Chatzistavrou, E. Factors Influencing the Accuracy of Cephalometric Prediction of Soft Tissue Profile Changes Following Orthognathic Surgery. *J. Maxillofac. Oral Surg.* **2012**, *11*, 82–90. [CrossRef]
16. Van Twisk, P.-H.; Tenhagen, M.; Gül, A.; Wolvius, E.; Koudstaal, M. How Accurate Is the Soft Tissue Prediction of Dolphin Imaging for Orthognathic Surgery? *Int. Orthod.* **2019**, *17*, 488–496. [CrossRef]
17. Olate, S.; Zaror, C.; Mommaerts, M. A Systematic Review of Soft-to-Hard Tissue Ratios in Orthognathic Surgery. Part IV: 3D Analysis-Is There Evidence? *J. Cranio-Maxillofac. Surg.* **2017**, *45*, 1278–1286. [CrossRef]
18. Stella, J.P.; Streater, M.R.; Epker, B.N.; Sinn, D.P. Predictability of Upper Lip Soft Tissue Changes with Maxillary Advancement. *J. Oral Maxillofac. Surg.* **1989**, *47*, 697–703. [CrossRef]
19. Freihofer, H.P.M. Changes in Nasal Profile after Maxillary Advancement in Cleft and Non-Cleft Patients. *J. Maxillofac. Surg.* **1977**, *5*, 20–27. [CrossRef]
20. Gjørup, H.; Athanasiou, A.E. Soft-Tissue and Dentoskeletal Profile Changes Associated with Mandibular Setback Osteotomy. *Am. J. Orthod. Dentofac. Orthop.* **1991**, *100*, 312–323. [CrossRef]
21. Chunmaneechote, P.; Friede, H. Mandibular Setback Osteotomy: Facial Soft Tissue Behavior and Possibility to Improve the Accuracy of the Soft Tissue Profile Prediction with the Use of a Computerized Cephalometric Program: Quick Ceph Image Pro: V. 2.5. *Clin. Orthod Res.* **1999**, *2*, 85–98. [CrossRef]
22. Joss, C.U.; Joss-Vassalli, I.M.; Berg, S.J.; Kuijpers-Jagtman, A.M. Soft Tissue Profile Changes after Bilateral Sagittal Split Osteotomy for Mandibular Setback: A Systematic Review. *J. Oral Maxillofac. Surg.* **2010**, *68*, 2792–2801. [CrossRef] [PubMed]