Evaluating the effectiveness of the surgery – First orthognathic approach in Skeletal Class III malocclusion treatment cases

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Evaluating the effectiveness of the surgery – First orthognathic approach in Skeletal Class III malocclusion treatment cases

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ABSTRACT

Objectives. Evaluating the effectiveness of the Surgery-First Orthognathic Approach (SFOA) in treating skeletal class III malocclusion cases on cephalometric radiographs.
Methods. The study consisted of 2 groups of skeletal class III malocclusion patients: 63 patients were treated by the surgery-first orthognathic approach and 20 patients underwent the orthodontic-first approach. Serial lateral cephalometric radiographs of each group at three time points (before surgery – after surgery – and right before debonding) were analyzed, superimposed, and compared to evaluate the skeletal dental and soft tissue changes of the two groups after treatment.
Results. There are effective improvements of many cephalometric skeletal-dental-soft tissue variables of patients treated by surgery-first, and there are no differences in the amount of skeletal-dental-soft tissue movements (except L1-NHL variable) compared with patients treated by orthodontic-first approach. Over 90% of patients treated by "surgery-first" achieved skeletal harmony variables and 69.6% of patients achieved upper and lower lip harmonious profiles, there are no differences between genders.
Conclusion. The surgery-first approach effectively improves skeletal correlation, occlusion, and soft tissue profile esthetic for skeletal class III malocclusion patients, and there is no difference in treatment outcome compared with the orthodontic-first approach.
Keywords: Skeletal class III malocclusion, surgery-first orthognathic approach, orthodontic-first approach, surgical orthodontics

INTRODUCTION

Malocclusion is a dental condition where there is an improper fit of two arches of teeth together. In America and Asian nations, the prevalence of malocclusion can exceed 70% of the population, and up to 35% of people have Class III malocclusion

[1]. Class III malocclusion is often accompanied by jawbone deviations and is one of the serious dento-maxillofacial malocclusions, greatly affecting facial aesthetics, chewing and pronunciation functions, and affecting speech. patient confidence in communication.

Traditional orthognathic surgery (TOS) is a three-phase treatment process involving pre-surgical orthodontics (PSO), surgery, and post-surgical orthodontics (PSOr). PSO typically lasts 12-24 months and aims to align and decompensate the teeth. Surgery involves repositioning the upper and/or lower jaw bones to correct the jaw misalignment. PSOr lasts 6-12 months and is necessary to refine the occlusion and achieve the desired aesthetic outcome. PSO can have a negative impact on the patient's quality of life due to its prolonged duration and potential to worsen the patient's facial profile. This can lead to psychological distress and functional limitations. Despite its drawbacks, TOS remains the gold standard treatment for severe jaw misalignment. It is a highly effective and predictable procedure that can significantly improve the patient's function, appearance, and quality of life [2].

Surgery-first orthognathic surgery (SFA) is a novel treatment approach that reverses the traditional sequence of orthognathic surgery. In SFA, Maxillomandibular discrepancy and severe dental compensations will be corrected by osteotomy first, and the orthodontic procedure will be done only after surgery. This approach has several advantages over traditional orthognathic surgery (TOS), including early improvement in aesthetic and functional outcomes: SFA results in an early improvement in the patient's main aesthetic needs and chewing function, as the maxillary and mandibular complex are repositioned immediately. Besides, SFA also capitalizes on the "regional acceleration" phenomenon that is one of the most important reason explained to help reduce the difficulties and time consuming of orthodontic treatment in surgical cases [3–5].

The systematic review of C.S.Huang (2014) and S. Barron (2020) revealed: almost the studies were case reports and retrospective cohort studies, and the skeletal class III malocclusions were majority due to their favorables in SFA application [4, 6–10]. In Vietnam, the majority of orthognathic surgery patients are treated with traditional orthodontic-first approach, while SFA has only been reported in clinical cases [11] Since the surgical orthodontics was applied many years in Odonto-Stomatology Hospital with the high level co-operation between surgeons and orthodontics; besides, all the orthognathic cases have been used rigid fixations. Therefore, we proceed this clinical trail study on skeletal class III malocclusion patients to assess the efficiency on lateral cephalometric radiographs of the surgery-first approach and compare with the traditional surgical orthodontics about dental – skeletal – soft tissue outcomes.

METHOD

Objectives

63 patients had needs and morphological characteristics suitable for orthodontic treatment combined with SFA (clinical intervention group) and 20 patients were treated with the combined of SFA with jaw surgery (control group) was conveniently selected from the group of patients with Angle class III malocclusion due to jaw bone who came

for examination and treatment at Ho Chi Minh City Central Hospital of Odonto-Stomatology, Ho Chi Minh City Odonto-Stomatology Hospital and Ho Chi Minh City University of Medicine and Pharmacy Hospital from 2015 to 2021.

Inclusion criteria

Patients must meet the following criteria:

- Need and indication for orthodontic treatment combined with surgery.
- Criteria for surgical anesthesia.
- Complete medical records and tilted skull radiographs.
- Cooperation in complying with treatment.

Intervention group: Patients with Class III malocclusion due to jawbone, with favorable needs and morphological characteristics, and who meet one of the following criteria are indicated for orthodontic treatment combined with SFA [7, 8, 12]:

- Class III malocclusion due to overdevelopment of the mandible.
- Mild to moderate tooth crowding in both jaws.
- Flat to medium deep Spee curve.
- Little to moderate tooth axis compensation.
- Little to moderate horizontal disharmony.

Control group: Patients with Class III malocclusion due to jawbone are treated with SFA combined with jaw surgery.

Exclusion criteria

Patients with the following conditions were excluded from the study

- Incomplete medical records
- Missing research data
- Uncooperative treatment
- Congenital malformations of the maxillofacial area
- Trauma, fractures, or gaps
- Jawbone pathology
- Full porcelain dental restoration
- Periodontal disease
- Progressive temporomandibular joint dysfunction

Intervention group: Patients with Angle class III malocclusion due to severe jawbone disharmony and complex and unfavorable occlusion, as evidenced by the following criteria, were indicated for orthodontic treatment combined with SFA:

- Severe tooth crowding
- Deep Spee curve
- Significant tooth axis compensation in both jaws
- An obstacle that increases the vertical dimension of the transitional occlusion
- Inability to establish a stable transitional occlusion

Control group: Patients who did not require SFA combined with jaw surgery were included in the control group.

Study design

Non-randomized clinical trial, with control group was conducted. This study used tilted skull films of patients at the time points before surgery - after surgery - after orthodontics.

Data analysis

Examining, diagnosing, and treating patients with Class III Angle malocclusion due to jawbone using the "pre-surgery" and "post-surgery" method. Analysis and superimposition of cranial tilt films of patients treated with "pre-surgery" and post-surgery methods. Data were entered and analyzed using R software.

RESULTS

According to Table 1, the SNA angle decreased significantly ($p < 0.05$) when compared between the pre-operative and post-orthodontic periods, and between the pre-surgical and post-surgical periods. The protrusion of point A relative to the skull base (Apoint - N perpend) also decreased significantly ($p < 0.05$) when compared between the pre-operative and post-orthodontic periods, and between the pre-surgical and post-surgical periods. The SNB angle, Pog-Nperpend, ANB angle, N-A-Pog angle, Wit's index, anterior-lower facial height, and upper and lower facial height ratio all increased significantly ($p < 0.001$) when compared between the pre-operative and post-surgical periods, and between the pre-surgical and post-orthodontic periods. The ratio of the height of the posterior surface to the anterior surface ($p = 0.004$) increased significantly when compared between the pre-operative and post-orthodontic periods. The mandibular plane angle (SN-GoGn) decreased significantly ($p = 0.002$) when compared between the pre-surgical and post-orthodontic periods.

Table 1. Bone tissue assessment indices at the time points before surgery - after surgery - after orthodontics in the group of patients with SFA

	Before surgery (N=63)	After surgery (N=63)	After orthodontics (N=63)	p13	p23
SNA (^{0})	83,04 ± 0,98	83,00 ± 0,94	82,96 ± 0,93	**0,003**	**0,017**
A Point-N Perpend (mm)	1,80 ± 1,03	1,74 ± 1,01	1,70 ± 1,00	**0,008**	0,068
Co-A (mm)	87,29 ± 4,64	87,19 ± 4,91	87,57 ± 4,99	0,317	**0,048**
SNB (^{0})	85,64 ± 2,05	80,86 ± 1,19	81,27 ± 1,09	**<0,001**	**<0,001**
Pog-N Perpend (mm)	9,65 ± 5,25	1,44 ± 3,39	2,29 ± 2,96	**<0,001**	**<0,001**
SN-GoGn (^{0})	36,90 ± 5,07	36,83 ± 3,35	36,48 ± 3,24	0,250	**0,002**

	Before surgery (N=63)	After surgery (N=63)	After orthodontics (N=63)	p13	p23
Co-Gn (mm)	134,01 ± 9,16	128,12 ± 8,57	128,34 ± 8,83	**<0,001**	0,373
ANB (^{0})	-2,60 ± 2,05	2,14 ± 1,14	1,69 ± 1,06	**<0,001**	**<0,001**
N-A-Pog (^{0})	-5,60 ± 4,79	1,86 ± 3,02	1,02 ± 2,83	**<0,001**	**<0,001**
Wits (mm)	-12,74 ± 3,09	-1,53 ± 1,35	-1,98 ± 1,28	**<0,001**	**<0,001**
ANS-Me (mm)	75,30 ± 7,66	74,24 ± 7,12	73,49 ± 6,91	**<0,001**	**0,001**
N-ANS/ANS-Me	0,77 ± 0,08	0,79 ± 0,07	0,80 ± 0,07	**<0,001**	**<0,001**
PFH/AFH (%)	64,23 ± 3,88	65,01 ± 3,00	65,56 ± 3,16	**0,004**	0,063

According to Table 2, Occlusal plane - skull base, upper incisor axis - palatal plane, and lower incisor height - mandibular plane values differed significantly ($p<0.05$) before and after surgery and orthodontics. Protrusion of upper incisors - skull base, axis of lower incisors - mandibular plane, angle of upper incisors - mandible (before surgery - after orthodontics and after surgery - after orthodontics), and protrusion of lower incisors - mandible (after surgery - after orthodontics) indicators also had a statistically significant difference ($p<0.001$) between the before and after measurements.

Table 2. Indicators of tooth tissue assessment before - after surgery and after orthodontics in the group of patients with SFA

	Before surgery (N=63)	After surgery (N=63)	After orthodontics (N=63)	p13	p23
Occ. Plane – SN (^{0})	15,31 ± 3,49	14,48 ± 2,22	14,45 ± 2,17	**0,013**	0,705
U1-NF (^{0})	122,09 ± 5,55	121,63 ± 5,31	120,76 ± 3,80	**0,010**	0,067
U1-NF (mm)	31,02 ± 3,70	30,93 ± 3,66	30,87 ± 3,57	0,416	0,701
U1 to NA (mm)	6,27 ± 2,33	6,09 ± 1,90	5,80 ± 1,75	**0,006**	**0,013**
L1 to MP (^{0})	81,39 ± 6,30	82,67 ± 5,63	87,04 ± 4,22	**<0,001**	**<0,001**
L1 to MP (mm)	44,28 ± 3,77	43,37 ± 3,91	43,50 ± 3,68	**0,014**	0,489
L1 to NB (mm)	6,58 ± 2,57	5,34 ± 1,65	6,05 ± 1,34	0,075	**<0,001**
Interincisal Angle	128,91 ± 7,64	128,20 ± 6,49	125,31 ± 3,96	**<0,001**	**<0,001**

Table 3 shows that all soft tissue index values changed significantly (p<0.001, except Sn-Stms/Stmi-Me' p=0.004) from before surgery to after orthodontics. The following indicators also had significant differences (p<0.05) between both the pre-operative and post-orthodontic and the post-operative and post-orthodontic time points: G-Sn/Sn-Me', Sn-Stms/Stmi-Me', lip-chin groove depth, and upper lip protrusion compared to aesthetic line E.

Table 3. Indicators of tooth tissue assessment before - after surgery and after orthodontics in the group of patients who received surgery first

	Before surgery (N=63)	After surgery (N=63)	After orthodontics (N=63)	p13	p23
G-Sn/Sn-Me'	1,03 ± 0,07	1,06 ± 0,08	1,07 ± 0,08	**<0,001**	**0,006**
Sn-Stms/Stmi-Me'	0,45 ± 0,04	0,47 ± 0,04	0,46 ± 0,04	**0,004**	**0,020**
STMs-U1 (mm)	2,38 ± 1,60	1,20 ± 1,26	1,37 ± 1,19	**<0,001**	0,152
Nasolabial Angle (^{0})	93,59 ± 9,79	99,24 ± 6,22	99,13 ± 6,27	**<0,001**	0,848
Mentolabial Sulcus (mm)	2,62 ± 0,81	3,39 ± 0,91	3,70 ± 0,87	**<0,001**	**0,001**
Upper Lip - E Plane (mm)	-4,71 ± 2,32	-1,40 ± 1,48	-1,85 ± 1,59	**<0,001**	**0,001**
Lower Lip - E Plane (mm)	0,42 ± 2,89	-1,67 ± 1,53	-1,71 ± 1,60	**<0,001**	0,792

According to Table 4, The vertical movement of the lower incisor position (NHL-L1) was significantly less (p = 0.017) in the pre-surgery patient group than in the post-surgery patient group. Additionally, there was no statistically significant difference in the movement of the bone-tooth-soft tissue components between the two groups at either pre-surgery or post-surgery post-orthodontic time points.

Table 4. Comparison of the level of bone - tooth - soft tissue movement of intervention group and the Control group between the two times after surgery and after orthodontics

	Intervention group (N=63)	Control group (N=20)	p-value
NVL-U1	-0,36 ± 0,94	-0,17 ± 0,93	0,422

NVL-L1	1,35 ± 1,31	1,38 ± 1,31	0,937
NVL-A point	-0,05 ± 0,15	-0,03 ± 0,17	0,765
NVL-B point	0,83 ± 0,85	0,90 ± 1,38	0,848
NVL-Pog	0,86 ± 1,14	1,03 ± 2,07	0,739
NVL-Ls	-0,58 ± 1,14	-0,62 ± 1,25	0,879
NVL-Li	-0,06 ± 1,10	0,26 ± 1,42	0,368
NVL-Soft A point	-0,41 ± 0,99	-0,70 ± 1,21	0,338
NVL-Soft B point	0,01 ± 1,32	0,51 ± 1,53	0,194
NVL-Soft Pog point	0,40 ± 1,46	0,62 ± 2,36	0,702
NHL-U1	0,20 ± 1,89	-0,19 ± 1,10	0,260
NHL-L1	-0,11 ± 2,00	-1,06 ± 1,29	**0,017**
NHL-A point	0,36 ± 1,17	0,19 ± 1,06	0,550
NHL-B point	-1,04 ± 2,84	-1,52 ± 2,17	0,437
NHL-Pog	-0,39 ± 2,34	-1,49 ± 2,34	0,078
NHL-Ls	0,30 ± 1,55	0,31 ± 1,91	0,980
NHL-Li	-0,45 ± 2,14	-0,66 ± 1,81	0,661
NHL-Soft A point	0,46 ± 1,42	0,55 ± 1,50	0,821
NHL-Soft B point	-0,61 ± 2,77	-1,05 ± 2,34	0,486
NHL-Soft Pog	-0,36 ± 2,80	-0,98 ± 2,28	0,329

Movement of landmarks compared to NVL (Nasion Vertical Line) in the front - back direction: (+) forward (-) backward. Movement of landmarks relative to the NHL (Nasion Horizontal Line) in the front - back direction: (+) down (-) up

According to Table 5, more than 90% of patients achieved population harmonization standards for mandibular bone-skull base correlation indices (SNB angle and Pog-Nperpend chin protrusion), upper face-lower face ratio (N-ANS/ANS-Me), and relationship between the maxilla and mandible (ANB angle, Wits index). 89.8% of patients achieved harmonious aesthetic standards for lip protrusion in profile. There was no statistically significant difference in the proportion of male and female patients who achieved harmonized standards for mandibular bone-skull base correlation indices, upper face-lower face ratio, and aesthetic lip protrusion in profile.

Table 5. Comparison of bone - tooth - soft tissue harmony ratio after orthodontic treatment of men and women in the intervention group

	Before surgery (N=63)	Male (N=17)	Female (N=46)	P-value
SNB and Pog-Nperpend	61 (96,8%)	16 (94,1%)	45 (97,8%)	0,470
ANB angle, Wits	59 (93,7%)	17 (100,0%)	42 (91,3%)	0,567
N-ANS/ANS-Me	61 (96,8%)	17 (100,0%)	44 (95,7%)	>0,999
Ls-E line, Li-E line	44 (69,8%)	12 (70,6%)	32 (69,6%)	>0,999

DISCUSSION

Characteristics on tilted skull films of patients treated with SFA

The SNA angle and the protrusion of point A relative to the skull base (Apoint-Nperpend) were slightly reduced after both orthodontic treatment and surgery. This is likely due to the retraction and uprighting of the upper incisors during orthodontic treatment, which is specifically designed to compensate for the forward tilt of the upper incisor axis in patients with Class III Angle malocclusion. When comparing the pre-orthodontic and post-orthodontic time points, the following values decreased significantly: SNB angle, Pog-Nperpend, ANB angle, N-A-Pog angle, Wits index, and facial height (both anterior and inferior). The upper-to-lower facial height ratio increased slightly, as did the ratio of posterior to anterior facial height. These results suggest that orthodontic treatment combined with pre-surgery can improve the maxillary-mandibular bone relationship, mandibular bone-skull base relationship, anterior and inferior facial height, and harmonious ratio of facial layers in patients with Class III jawbone misalignment. These findings are consistent with the studies of authors Ellen W.C. Ko and Liao Y.F [5, 13].

The mandibular plane angle (SN-GoGn) decreased slightly but significantly ($p = 0.002$) from the post-operative to post-orthodontic time points, indicating slight anterior closure of the mandible after push-up surgery. This suggests that there was some recurrence of mandibular anterior protrusion, but it was effectively controlled by orthodontic treatment after pre-surgery. These findings are similar to those of the study by Ellen W.C. Ko [13].

Dental tissue characteristics

Orthodontic treatment to compensate for teeth after pre-surgery in the treatment of Class III Angle malocclusion due to jaw bone typically involves retracting and uprighting the upper incisors, and proclining and uprighting the lower incisors. This is done to:

- Decrease the tilt, protrusion, and height of the upper incisors relative to the maxillary bone base, to compensate for the external tilt of the upper incisors.

- Increase the tilt, protrusion, and height of the lower incisors to erect the axis of the lower incisors.
- Slightly reduce the angle between the upper and lower incisors due to the elevation of the lower tooth axis.

These changes are consistent with the principles of orthodontic treatment to compensate for teeth after pre-surgery in the treatment of Class III Angle malocclusion due to jaw bone [13]. The occlusal plane angle decreased slightly after surgery due to the upward rotation of the mandible after surgery to push back the mandible.

Soft tissue characteristics

Orthodontics combined with pre-surgery significantly improved the soft tissue proportions of the facial layers in profile, lip relationship and aesthetic line E, nasolabial angle, tooth exposure compared to upper lip border, and depth of chin-lip groove. These findings are consistent with the studies of Ellen W.C. Ko and Liao Y.F [5, 13]. This suggests that orthodontics combined with pre-surgery is an effective way to improve the aesthetics of the soft tissues in patients with Class III jawbone misalignment. This is likely due to the fact that orthodontic treatment can improve the position of the teeth and jaws, which can in turn lead to a more harmonious relationship between the soft tissues. The results of this study are particularly significant because they were obtained using tilted skull films. This type of film is used to assess the facial profile, and it is therefore more sensitive to changes in the soft tissues than traditional frontal and cephalometric films. The fact that all the soft tissue analysis values showed changes between the pre-operative and post-orthodontic periods suggests that orthodontic treatment has a significant impact on the soft tissues. This is important to consider for patients who are undergoing pre-surgery for Class III jawbone misalignment, as it suggests that orthodontics can help to achieve a more aesthetically pleasing result.

Amplitude of bone-tooth-soft tissue movement of the intervention group and the control group at the time points after surgery - after orthodontics

In the pre-surgery group, the vertical movement of the lower incisor biting edge (NHL-L1) was -0.11mm ± 2.00mm, which was 1.06mm ± 1.29mm less than the post-surgery group. This is likely due to the fact that there is a "transitional" bite after surgery with a large positive overbite. The orthodontic procedure after surgery helps to control the position of the lower incisors more easily, which may explain why the post-surgery group had a greater increase in the vertical movement of the lower incisor biting edge [5, 13].

There was no statistically significant difference in the movement of the remaining bone-tooth-soft tissue components between the pre-surgery and post-surgery patient groups between the two time points after surgery and orthodontics. This suggests that the level of bone movement recurrence or the stability of the jaw position-bite-soft tissue aesthetics after surgery was similar between the two groups. These findings are consistent with those of the study by Ellen W.C. Ko and Liao Y.F [5, 13]. However, the results of our study also showed that there was no vertical movement of Pogonion

point and B point, different from Liao Y.F.'s study, the reason being that all patients in Liao's study were Class III open bite jaw bone, so planning the "transitional" bite after surgery needs to be more favorable for moving and closing the open bite of the anterior teeth, leading to post-operative vertical movement of the mandible increase.

Percentage of patients treated with the SFA method meeting the criteria of harmony in jaw bone and double lip aesthetics in profile

This study evaluated the degree of improvement in jaw bone relationship and double lip aesthetics from a side view after combined orthodontic treatment in patients who underwent lower jaw surgery using the BSSO (Bilateral Sagital Split Osteotomy) method. In accordance with prior surgery, patients were divided into two groups including patients who underwent orthodontic treatment before surgery and patients who underwent orthodontic treatment after surgery. The following components were assessed for each group including mandibular bone-skull base relationship (SNB angle and Pog-Nperpend chin protrusion), relationship between maxilla and mandible (ANB angle and Wits index), ratio of upper surface to lower surface (N-ANS/ANS-Me), and aesthetic protrusion of the two lips (protrusion of the upper and lower lips compared to the E aesthetic line).

The criteria for achieving group harmony was when the patient had all components in the group achieving harmony. The proportion of patients treated with SFA in the study met population harmonization standards. Thus, the orthodontic method combined with SFA to thoroughly improve the vertical and anterior-posterior jawbone position for most patients. However, the level of improvement in bilateral lip aesthetics in profile was only satisfactory in 69.8% of patients, showing the need for further evaluation of lip soft tissue, tip of nose height, and chin protrusion.

The proportion of male and female patients in the study met population harmonization standards for groups (mandibular bone-skull base relationship, bimandibular bone relationship, upper-lower facial ratio, double protrusion aesthetic) are similar, showing that the degree of functional and aesthetic improvement of the "pre-surgery" method is effective in both sexes.

CONCLUSION

Combined orthodontic treatment and SFA (surgery-first approach) is an effective way to improve jaw bone relationship, bite, and profile facial aesthetics in patients with Angle class III malocclusion due to the jaw bone, especially in cases where Class III is due to overdevelopment of the mandible. There is no difference in the relationship of the two jaw bones, bite, and the recurrence of mandibular anterior protrusion after orthodontic treatment combined with "pre-surgery" or "post-surgery."

Ethical Approval: This study was approved by the behavioral IRB of the Institute of Population, Health and Development, Vietnam. The number of IRB is 2016/PHAD/MALOC-05-01.

Conflict of interest: Authors have declared no conflicts of interest.

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