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Five-year skeletal and dental stability following bilateral sagittal split osteotomy for mandibular advancement in Class 2 malocclusion

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ABSTRACT

Background: Bilateral sagittal split osteotomy (BSSO) is widely used for mandibular advancement in patients with skeletal Class 2 malocclusion; however, long-term postoperative stability remains an important clinical concern.
Purpose: To evaluate long-term skeletal, dentoalveolar, and soft tissue stability following mandibular advancement with BSSO and rigid fixation.
Methods: A retrospective cohort study was conducted in 32 patients undergoing mandibular advancement with BSSO and rigid fixation. Cephalometric measurements were obtained at four time points: preoperative, immediate postoperative, 12 months, and long-term follow-up (>3 years). Changes were analyzed using the Wilcoxon signed-rank test.
Results: The mean mandibular advancement was 5.42 ± 1.71 mm. Immediately after surgery, significant skeletal correction was achieved, with increased SNB and decreased ANB (both $p < 0.001$), accompanied by significant improvements in occlusal and soft tissue profile measurements. Most skeletal and occlusal parameters remained stable during the first postoperative year and throughout long-term follow-up, with no statistically significant changes observed between one year and the final evaluation. Soft tissue remodeling continued during follow-up, whereas overall skeletal and dental stability was maintained.
Conclusion: Bilateral sagittal split osteotomy with rigid fixation effectively corrected skeletal Class 2 malocclusion and demonstrated favorable long-term skeletal, dental, and soft tissue stability.

1. Introduction

Skeletal Class 2 malocclusion is one of the common craniofacial abnormalities, characterized by the protrusion of the maxilla and the retrusion of the mandible, or a combination of both, resulting in a distinctive convex profile[1,2] This condition not only affects chewing function, articulation, and occlusion but also significantly impacts the aesthetic appearance of the face and the quality of life of patients.[3] In cases of mild to moderate deviations, orthodontic treatment may partially compensate for skeletal discrepancies; [4–6] however, in cases of severe skeletal deformities, orthognathic surgery is essential to achieve optimal jaw relationship and occlusion as well as long-term stability.[1]

Bilateral Sagittal Split Osteotomy (BSSO), first described by Trauner and Obwegeser in 1957,[7] is now the most common technique for treating mandibular retrusion in Class 2 skeletal deformities, as it allows for forward movement of the mandible with good control and high stability.[8] However, postoperative results may be influenced by various factors such as the degree and direction of bone movement, fixation methods, condylar position, muscle dynamics around the jaw, as well as the healing and remodeling process post-surgery.[7,9]

Relapse after surgery, particularly in mandibular advancement cases, remains a significant concern. Early relapse may occur due to muscle

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tonus imbalance or condylar position deviation, while late relapse may be associated with ongoing growth of the mandible, condylar resorption, or changes in the temporomandibular joint. Studies have shown that the greater the mandibular movement, the higher the risk of relapse; specifically, advancements exceeding 10 mm are associated with a significantly greater risk of instability than smaller movements.[10,11]

Most published studies evaluating the outcomes of bilateral sagittal split osteotomy have reported short-to medium-term follow-up periods, typically ranging from 6–12 months to 2 years. Although several studies have assessed longer follow-up periods, evidence regarding postoperative stability beyond 3 years remains limited, particularly with respect to combined skeletal, dentoalveolar, and soft tissue changes. Late skeletal remodeling and soft tissue adaptation may continue after the first postoperative year and may influence facial aesthetics and long-term treatment outcomes.[12,13] In addition, contemporary orthognathic surgery research has increasingly emphasized not only morphologic stability but also patient-centered outcomes, including health-related quality of life and treatment satisfaction. [14–18].

Therefore, this study was conducted to provide additional evidence regarding the long-term skeletal, dentoalveolar, and soft tissue stability following mandibular advancement using bilateral sagittal split osteotomy with rigid fixation in patients with skeletal Class 2 malocclusion.

2. Material and methods

2.1. Study design

This retrospective cohort study was conducted at the Department of Plastic Surgery, Van Hanh General Hospital, Ho Chi Minh City, Vietnam, using clinical records and lateral cephalometric radiographs of patients treated between 2018 and 2024. The study protocol was approved by the hospital's Biomedical Research Ethics Committee before retrospective data collection and analysis and was conducted in accordance with the principles of the Declaration of Helsinki.

2.2. Participants

2.2.1. The inclusion criteria were as follows

Patients aged ≥18 years.

Diagnosis of Class 2 malocclusion due to mandibular retrusion.

Surgical treatment for mandibular advancement using Bilateral Sagittal Split Osteotomy (BSSO) with internal rigid fixation.

All patients had complete long-term follow-up records during the study period.

Availability of standardized lateral cephalometric radiographs at the following time points:

- Pre-surgery (T1)
- Post-surgery 7–10 days (T2)
- 12 months post-surgery (T3)
- Long-term follow-up (>3 years) (T4)

2.2.2. Exclusion criteria included

Congenital craniofacial deformities.

History of trauma or fractures in the jaw region.

Previous bimaxillary orthognathic surgery.

Systemic diseases affecting bone healing.

Incomplete follow-up records.

2.3. Sampling and sample size

Convenience sampling was employed, including all patients who met the eligibility criteria. A total of 32 patients (18 females and 14 males) were included in the analysis. Retrospective data collection and extraction of clinical records and cephalometric radiographs were conducted from January to April 2026 after Institutional Ethics Committee approval.

2.4. Presurgical orthodontic treatment

All patients underwent presurgical orthodontic treatment for dental decompensation before orthognathic surgery. Fixed orthodontic appliances were used in all cases. Tooth extraction was performed when indicated based on the individual orthodontic treatment plan and degree of crowding or dentoalveolar compensation. Presurgical orthodontic treatment aimed to achieve proper dental alignment and coordination of both arches before surgical mandibular advancement.

2.5. Data collection and cephalometric assessment

Digital lateral cephalometric radiographs were obtained using standardized procedures with the same cephalometric X-ray unit. Standardized head positioning and manufacturer-recommended magnification calibration were applied to ensure measurement consistency. All radiographs were obtained as part of routine clinical care rather than specifically for research purposes.

Cephalometric analysis was performed by a trained investigator using standard skeletal, dental, and soft-tissue landmarks and reference planes. The cephalometric landmarks, reference planes, and linear and angular measurements used in this study are illustrated in Figs. 1–3. Fig. 1 shows the hard-tissue landmarks and reference planes used to measure the SNA, SNB, ANB, ML–NSL, and N–A–Pog angles.[19] Fig. 2 illustrates the dental measurements of overjet (OJ) and overbite (OB).[20] Fig. 3 presents the soft-tissue profile measurements, including the N′–Sn–Pog′ and N′–Pn–Pog′ angles and the lower lip-to-E-line distance (LL–E line).[21]

The immediate preoperative cephalogram (T1), obtained after completion of presurgical orthodontic treatment, served as the baseline for all analyses and represented the standardized skeletal and dental relationship immediately before surgery. Mandibular advancement was assessed by comparing T1 and T2, whereas postoperative adaptation and long-term stability were evaluated using the T2–T3 and T3–T4 intervals.

As this was a retrospective study, the immediate postoperative cephalogram (T2) was used to assess the direct skeletal effects of surgery before substantial postoperative orthodontic tooth movement occurred. Relapse was defined as a change opposite to the direction of surgical movement during follow-up, with clinically significant relapse defined as a change exceeding 2 mm for linear measurements or 2° for angular measurements.

2.6. Surgical procedure

All BSSO procedures were performed by the same surgeon and surgical team to ensure consistency of surgical technique. Mandibular third molars were extracted preoperatively when indicated.

During surgery, a surgical splint was used to position the mandible in the planned position. Internal fixation was achieved using titanium miniplates and monocortical screws (4-hole/4-screw or 6-hole/4-screw configurations depending on the clinical situation). After removal of the surgical splint, occlusion and centric relation were verified before temporary intermaxillary fixation was applied.

2.7. Postsurgical orthodontic treatment

After surgery, all patients underwent postsurgical orthodontic treatment for occlusal settling and finishing. Intermaxillary elastics were used when indicated to improve intercuspation and occlusal stability. Orthodontic appliances were removed after satisfactory functional occlusion had been achieved, followed by retention according to the orthodontic treatment protocol.

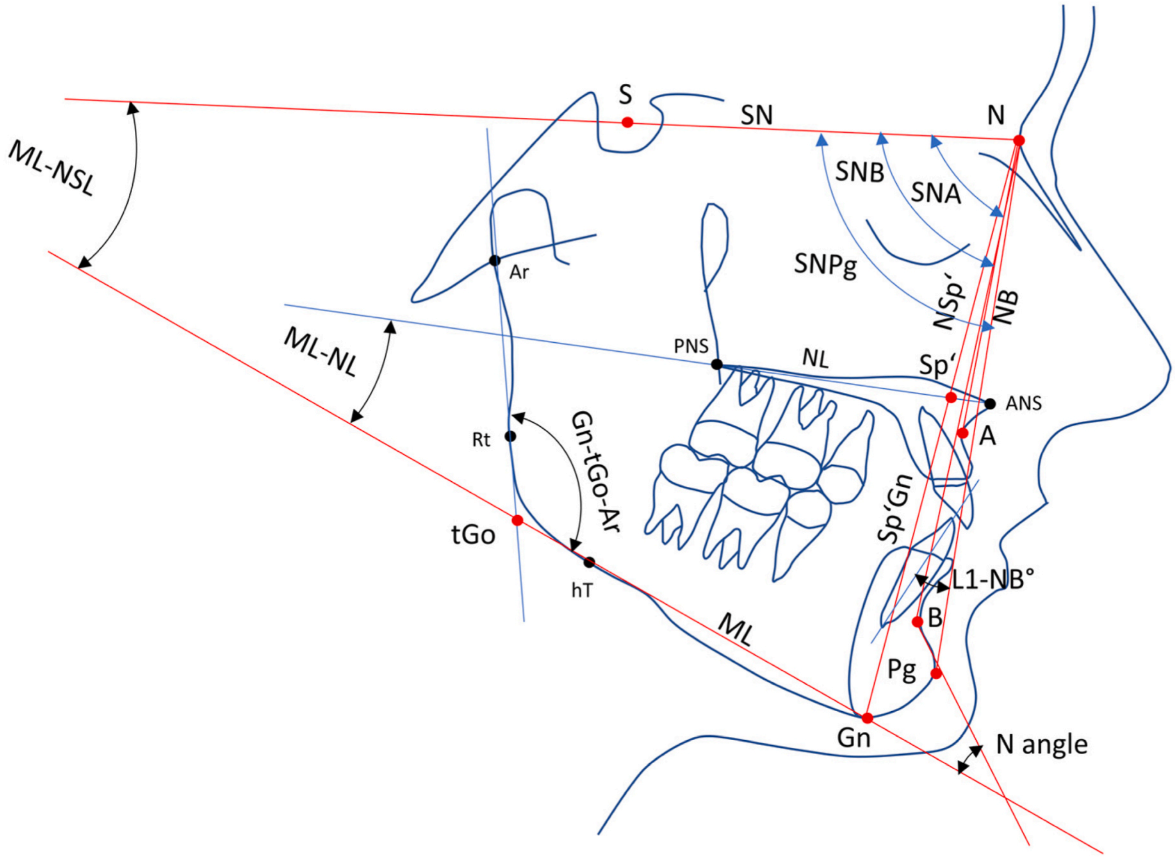

Fig. 1. Hard tissue landmarks, reference planes and SNA, SNB, ANB, ML-NSL and N-A-Pog angle measurements.

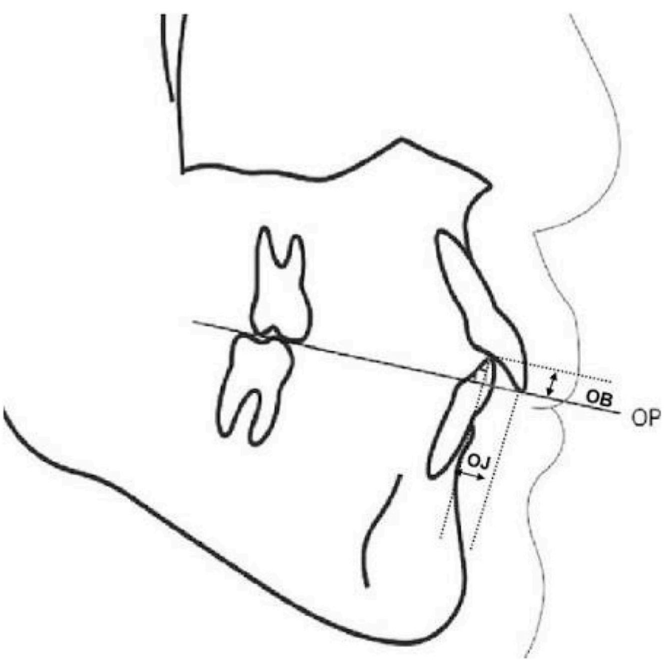

Fig. 2. Overjet (OJ) and overbite (OB) assessment.

2.8. *Statistical analysis*

Statistical analyses were performed using SPSS Statistics version 22. Descriptive statistics were presented as means and standard deviations. Data normality was assessed using the Shapiro–Wilk test. Because the data were not normally distributed, differences between time points were analyzed using the Wilcoxon signed-rank test. A p-value <0.05 was considered statistically significant. Bonferroni correction was applied for multiple comparisons.

To assess measurement reliability, 32 lateral cephalometric radiographs at T2, T3, and T4 were re-evaluated by the same investigator after a two-week interval. Intra-examiner reliability was assessed using the intraclass correlation coefficient (ICC) and the Wilcoxon signed-rank test. No statistically significant differences were found between repeated measurements, and excellent reliability was observed (ICC = 0.975–0.998). The study was reported in accordance with the STROBE guidelines.

2.9. *Ethics of research*

This retrospective cohort study was approved by the Biomedical Ethics Committee (Decision No. 230/GCN.ĐC-HĐDĐ, dated October 21, 2025). The study involved retrospective review of existing clinical records and radiographs. All data were anonymized before analysis, and patient confidentiality was strictly maintained throughout the study. The study was conducted in accordance with the principles of the Declaration of Helsinki.

3. Results

A total of 32 patients (18 females and 14 males) were included in the study, with a mean age of 23.1 ± 5.4 years and a mean follow-up duration of 5.1 ± 0.9 years (Table 1).

3.1. *Changes in hard and soft tissue measurements during follow-up*

Table 2 summarizes the hard and soft tissue measurements at each

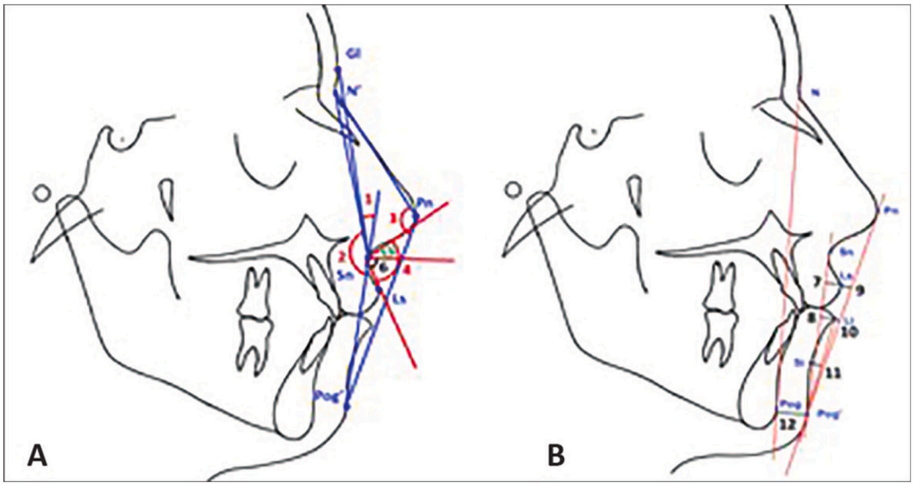

Fig. 3. Soft tissue assessment. (A) 2. N'SnPog', 3. N'PnPog' and (B) 10. Li -PnPog' (LL-E line).

Table 1
Baseline demographic and clinical characteristics of the study population.

Characteristic	Total (N = 32)	Male (n = 14)	Female (n = 18)	*p*-value
Age (years)	23.1 ± 5.4	24.5 ± 5.6	22.0 ± 5.0	0.184
Follow-up duration (years)	5.1 ± 0.9	5.0 ± 0.8	5.2 ± 1.0	0.543
Pre-surgical orthodontic duration (months)	21.4 ± 5.2	22.8 ± 5.5	20.3 ± 4.8	0.176
Post-surgical orthodontic duration (months)	7.5 ± 2.1	7.8 ± 2.3	7.2 ± 1.9	0.428
Mandibular advancement (mm)	5.42 ± 1.71	5.75 ± 1.85	5.16 ± 1.55	0.334
Preoperative SNA (°)	81.2 ± 3.4	81.6 ± 3.6	80.9 ± 3.2	0.561
Preoperative SNB (°)	74.5 ± 2.8	74.2 ± 3.0	74.7 ± 2.6	0.618
Preoperative ANB (°)	6.7 ± 1.5	6.9 ± 1.6	6.5 ± 1.4	0.463
Preoperative Overjet (mm)	7.2 ± 1.8	7.6 ± 1.9	6.9 ± 1.6	0.264
Preoperative Overbite (mm)	4.8 ± 1.5	5.0 ± 1.6	4.6 ± 1.4	0.465

Data are presented as Mean ± Standard Deviation (SD).
p-values were derived from independent Student's t-tests. $P < 0.05$ is statistically significant.

follow-up time point together with the changes observed between consecutive assessment periods. Sex-based comparisons of hard and soft tissue changes during follow-up are presented in Table 3.

3.2. Immediate postoperative changes (T1–T2)

The mean mandibular advancement achieved during surgery was 5.42 ± 1.71 mm. Immediately after surgery, significant skeletal changes were observed, with SNB increasing from 74.17 ± 2.80° to 76.97 ± 3.17° (mean change: 2.81 ± 1.20°, $p < 0.001$) and ANB decreasing from 7.61 ± 3.45° to 4.65 ± 3.74° (mean change: −2.96 ± 1.07°, $p < 0.001$), indicating successful sagittal correction following mandibular advancement. No significant changes were observed in SNA or ML/NSL (both $p > 0.05$).

Occlusal relationships also improved significantly after surgery. Overjet and overbite were markedly reduced (both $p < 0.001$), reflecting successful correction of the Class 2 malocclusion. Significant improvements were also observed in soft tissue profile measurements, including N–A–Pog, N′–Sn–Pog′, and N′–Pn–Pog′ (all $p < 0.001$).

3.3. Changes during the first postoperative year (T2–T3)

During the first postoperative year, skeletal measurements remained generally stable. No statistically significant changes were observed in SNA, SNB, ANB, or ML/NSL (all $p > 0.05$). Among the dentoskeletal variables, only overjet demonstrated a small but statistically significant increase (0.87 ± 1.12 mm, $p < 0.001$). Soft tissue adaptation continued during this period, as evidenced by significant reductions in LL–E-line (−1.24 ± 1.81 mm, $p < 0.001$) and N–A–Pog angle (−0.58 ± 1.42°, $p = 0.018$), whereas the remaining soft tissue parameters showed no significant changes.

3.4. Long-term changes (T3–T4)

Between the one-year and long-term follow-up evaluations, skeletal and occlusal measurements remained stable, with no statistically significant changes observed in SNA, SNB, ANB, ML/NSL, overjet, or overbite (all $p > 0.05$). Most soft tissue parameters also remained stable. However, LL–E-line (−0.92 ± 1.10 mm, $p < 0.001$) and N′–Sn–Pog′ (2.11 ± 2.90°, $p < 0.001$) continued to show statistically significant changes, suggesting ongoing soft tissue remodeling despite stable skeletal outcomes. Overall, the findings demonstrate favorable long-term skeletal, dental, and soft tissue stability following bilateral sagittal split osteotomy for mandibular advancement.

3.5. Complications

Postoperative sensory disturbance was observed in 81.25% of patients. Among these patients, 62.5% achieved complete recovery, whereas 18.75% presented mild residual dysesthesia at long-term follow-up. No major postoperative complications were reported.

4. Discussion

This study evaluated the long-term stability of mandibular advancement using bilateral sagittal split osteotomy (BSSO) over a follow-up period of 3 to 6 years. The findings demonstrated stable skeletal and dental outcomes, with minor long-term soft tissue changes that were not clinically significant. No clinically significant relapse was observed during follow-up. These results support previous evidence indicating that BSSO is a highly stable and predictable technique for the correction of mandibular retrusion in Class 2 skeletal deformities.[22,23]

BSSO is associated with several postoperative complications, including inferior alveolar nerve dysesthesia, unfavorable fractures (bad split), infection, relapse, and temporomandibular joint disorders.[24]

Table 2
Hard and soft tissue measurements at each follow-up time point and changes between time points (n = 32).

Variables	Time points				Changes between time points					
	T1Mean ± SD	T2Mean ± SD	T3Mean ± SD	T4Mean ± SD	T1–T2Mean ± SD	p-value	T2–T3Mean ± SD	p-value	T3–T4Mean ± SD	p-value
SNA (°)	81.77 ± 2.77	81.68 ± 2.83	81.74 ± 2.76	81.67 ± 2.79	−0.09 ± 0.36	0.120	0.06 ± 0.27	0.810	−0.07 ± 0.41	0.610
SNB (°)	74.17 ± 2.80	76.97 ± 3.17	77.17 ± 3.31	77.00 ± 3.27	2.81 ± 1.20	<0.001	0.19 ± 0.88	0.120	−0.16 ± 0.52	0.200
ANB (°)	7.61 ± 3.45	4.65 ± 3.74	4.51 ± 3.96	4.62 ± 4.04	−2.96 ± 1.07	<0.001	−0.14 ± 0.75	0.063	0.11 ± 0.40	0.120
ML-NSL (°)	31.46 ± 4.38	31.77 ± 4.14	32.13 ± 4.38	31.87 ± 4.71	0.31 ± 1.01	0.320	0.36 ± 1.02	0.310	−0.26 ± 0.97	0.100
Overjet (mm)	8.32 ± 1.71	2.62 ± 2.67	2.85 ± 2.94	3.07 ± 3.04	−5.69 ± 2.25	<0.001	0.22 ± 1.01	0.350	0.22 ± 0.81	0.160
Overbite (mm)	4.23 ± 1.47	2.02 ± 2.68	2.89 ± 2.84	3.05 ± 2.88	−2.21 ± 1.96	<0.001	0.87 ± 1.12	<0.001	0.16 ± 0.62	0.250
LL–E-line (mm)	2.74 ± 1.54	2.38 ± 2.70	1.14 ± 2.70	0.22 ± 3.02	−0.36 ± 2.24	0.210	−1.24 ± 1.81	<0.001	−0.92 ± 1.10	<0.001
N–A–Pog (°)	11.12 ± 2.94	6.35 ± 4.04	5.77 ± 4.27	6.03 ± 4.38	−4.77 ± 2.59	<0.001	−0.58 ± 1.42	0.018	0.26 ± 0.95	0.190
N′–Sn–Pog′ (°)	150.43 ± 3.81	156.44 ± 4.00	157.00 ± 4.06	159.11 ± 4.99	6.01 ± 1.78	<0.001	0.56 ± 2.22	0.620	2.11 ± 2.90	<0.001
N′–Pn–Pog′ (°)	135.90 ± 3.60	139.85 ± 4.20	140.07 ± 4.02	140.49 ± 3.52	3.95 ± 2.44	<0.001	0.22 ± 1.17	0.100	0.42 ± 1.93	0.300

* SD: standard deviation; T1: immediately before surgery; T2: immediately after surgery; T3: one year after surgery; T4: long-term follow-up (≥3 years).
Interpretation of comparison intervals: T1–T2, immediate surgical changes; T2–T3, short-term postoperative adaptation; T3–T4, long-term postoperative stability; T2–T4, overall postoperative changes from the immediate postoperative period to long-term follow-up.

Table 3
Comparison of hard and soft tissue changes between male and female patients during follow-up.

Measurement	Male (n = 14) Mean ± SD	Female (n = 18) Mean ± SD	p-value
T1–T2 Changes (Surgical)			
SNA (°)	−0.11 ± 0.35	−0.07 ± 0.37	0.751
SNB (°)	2.88 ± 1.25	2.75 ± 1.15	0.764
ANB (°)	−3.02 ± 1.10	−2.91 ± 1.04	0.776
ML-NSL (°)	0.35 ± 1.05	0.28 ± 0.97	0.842
Overbite (mm)	−5.85 ± 2.30	−5.56 ± 2.20	0.718
Overjet (mm)	−2.35 ± 2.05	−2.10 ± 1.88	0.715
LL-E-line (mm)	−0.45 ± 2.30	−0.29 ± 2.19	0.835
N–A–Pog (°)	−4.92 ± 2.65	−4.65 ± 2.54	0.769
N'–Sn–Pog' (°)	6.15 ± 1.85	5.90 ± 1.72	0.688
N'–Pn–Pog' (°)	4.10 ± 2.50	3.83 ± 2.39	0.753
T2–T3 Changes (1-Year)			
SNA (°)	0.05 ± 0.25	0.07 ± 0.29	0.833
SNB (°)	0.22 ± 0.90	0.17 ± 0.86	0.871
ANB (°)	−0.16 ± 0.78	−0.12 ± 0.72	0.880
ML-NSL (°)	0.38 ± 1.05	0.34 ± 0.99	0.910
Overbite (mm)	0.25 ± 1.05	0.20 ± 0.98	0.887
Overjet (mm)	0.92 ± 1.18	0.83 ± 1.07	0.824
LL-E-line (mm)	−1.35 ± 1.85	−1.15 ± 1.78	0.755
N–A–Pog (°)	−0.65 ± 1.48	−0.53 ± 1.37	0.812
N'–Sn–Pog' (°)	0.62 ± 2.30	0.51 ± 2.15	0.889
N'–Pn–Pog' (°)	0.25 ± 1.20	0.20 ± 1.15	0.905
T3–T4 Changes (Long-term)			
SNA (°)	−0.08 ± 0.42	−0.06 ± 0.40	0.890
SNB (°)	−0.18 ± 0.55	−0.14 ± 0.49	0.826
ANB (°)	0.13 ± 0.42	0.09 ± 0.38	0.781
ML-NSL (°)	−0.28 ± 0.99	−0.24 ± 0.95	0.908
Overbite (mm)	0.24 ± 0.85	0.20 ± 0.78	0.889
Overjet (mm)	0.18 ± 0.65	0.14 ± 0.59	0.855
LL-E-line (mm)	−0.98 ± 1.15	−0.87 ± 1.06	0.783
N–A–Pog (°)	0.29 ± 0.98	0.24 ± 0.93	0.884
N'–Sn–Pog' (°)	2.25 ± 3.05	2.00 ± 2.78	0.817
N'–Pn–Pog' (°)	0.48 ± 2.01	0.37 ± 1.86	0.874

SD: standard deviation; T1: pre-surgery; T2: immediate post-surgery; T3: 12 months post-surgery; T4: long-term follow-up (≥3 years).

These complications may occur during both early and late postoperative phases and may influence postoperative recovery and patient satisfaction. However, most neurosensory disturbances tend to improve over time.[25] In the present study, 81.25% of patients experienced sensory disturbances immediately after surgery, while only 18.75% reported persistent mild dysesthesia at long-term follow-up. These findings are consistent with previous reports, such as that by Al-Bishri et al., which documented a wide range of neurosensory disturbance rates depending on evaluation methods and follow-up duration.[26]

Significant improvements in skeletal and dental parameters (SNB, ANB, overbite, and overjet) were observed immediately after surgery, confirming the effectiveness of mandibular advancement in restoring maxillomandibular relationships and functional occlusion. Concurrent improvements in soft tissue parameters, including the N–A–Pog, N′–Sn–Pog', and N′–Pn–Pog' angles, were also observed immediately after surgery, although early postoperative soft tissue measurements should be interpreted cautiously because of postoperative edema and tissue adaptation. During the first postoperative year (T2–T3), only minor changes were detected, primarily in overjet and selected soft tissue variables, likely reflecting postoperative adaptation and neuromuscular remodeling.

At long-term follow-up (T3–T4), skeletal and occlusal parameters remained stable, with no statistically or clinically significant changes observed. Based on established criteria (≥2 mm or ≥2°), no cases of clinically meaningful relapse were identified, reinforcing that mandibular advancement with rigid fixation belongs to a group of highly stable orthognathic procedures.[27]

Although LL–E-line and N′–Sn–Pog' demonstrated statistically significant changes during long-term follow-up, the magnitude of these changes remained small and below the threshold considered clinically meaningful. These findings likely reflect gradual soft tissue adaptation and aging-related remodeling rather than true skeletal relapse. This distinction between statistical significance and clinical relevance is important when interpreting long-term outcomes of orthognathic surgery.[28]

Several factors may explain the high stability observed in this study. First, the magnitude of mandibular advancement was relatively moderate (mean 5.42 ± 1.71 mm), which is below the threshold associated with increased relapse risk.[29] Second, all patients were treated using rigid internal fixation, a method known to improve postoperative skeletal stability compared with non-rigid fixation techniques.[30] Third, all procedures were performed by a single surgical team, thereby reducing variability in surgical technique and postoperative management.

This study has several limitations. The retrospective design and relatively small sample size may limit the generalizability of the findings. In addition, the use of immediate postoperative radiographs for soft tissue assessment may have been influenced by postoperative edema and early tissue adaptation. Furthermore, two-dimensional cephalometric analysis does not fully capture three-dimensional skeletal changes, condylar remodeling, or temporomandibular joint adaptation following orthognathic surgery.[31] Future studies incorporating larger multicenter cohorts and three-dimensional imaging techniques are warranted to provide a more comprehensive evaluation of long-term surgical outcomes.

5. Conclusion

Bilateral sagittal split osteotomy (BSSO) with rigid internal fixation achieved significant improvement in skeletal Class 2 malocclusion, resulting in favorable correction of mandibular retrusion, occlusion, and facial profile.

The mean mandibular advancement achieved was 5.42 ± 1.71 mm, with significant postoperative improvements in cephalometric parameters, including SNB (+2.81°), ANB (−2.96°), overbite, and overjet (all $p < 0.001$).

Skeletal and occlusal outcomes remained stable during long-term follow-up (3–6 years), with no clinically significant relapse (≥2 mm or ≥2°) identified between T3 and T4.

Minor soft tissue changes continued during long-term follow-up, particularly in LL–E-line and N′–Sn–Pog' measurements; however, these changes were small and not clinically significant.

Postoperative sensory disturbance was common during the early postoperative period, although most patients demonstrated recovery during long-term follow-up.

Ethical approval

The study protocol was approved by the Biomedical Ethics Committee of Tra Vinh University, Vietnam – Approval No. 230/GCN.ĐC-HĐĐĐ, dated October 21, 2025.

Authors' contribution

Tan Hung Le and My Huyen Nguyen designed the study. Tan Hung Le, Tran Thuy Vy Le, Duc Lanh Le, and Ai Khiem Tran conducted data collection and ensured rigorous and accurate exclusion based on the study criteria. Thi Hong Tuyen Nguyen performed the analysis, interpretation, and writing of the manuscript. Hoang Giang Nguyen evaluated the content. Thi Hong Tuyen Nguyen and Tan Hung Le developed the final version, which was approved by all authors.

Consent for publication

Written informed consent for publication was obtained from all participants before data collection.

Declaration on the use of AI

No AI-based tools or chatbots were used to create the content or analyze the data in this manuscript.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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