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Research Article

Post-Orthodontic Evaluation of Incisor Position on Class I Malocclusion Patients: A Radiographic Study

Valerie Kartini,[1] Miesje Karmiati Purwanegara,[2] Muhammad Sulaiman Kusumah Adiwirya[*2]

[1] *Undergraduate student, Faculty of Dentistry, Universitas Indonesia, Jakarta, Indonesia*
[2] *Department of Orthodontic, Faculty of Dentistry, Universitas Indonesisa, Jakarta, Indonesia*

KEYWORDS

Incisor inclination and angulation, fixed orthodontic treatment, cephalometric analysis, orthodontic outcome, Indonesia

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ABSTRACT

Background: Malocclusion is the irregularity of teeth, considered as an oral health problem resulting from various etiological factors, causing esthetic dissatisfaction to functional impairment. Malocclusions must be fixed by orthodontic treatment. Achieving proper incisor inclination and angulation is essential for orthodontic treatment stability and facial harmony. However, limited evidence exists regarding post-treatment incisor positioning in Class I skeletal malocclusion patients within the Indonesian population. **Objective:** This study aimed to analyze the post-treatment inclination and angulation of maxillary and mandibular incisors in Class I skeletal malocclusion patients and to evaluate whether these parameters fall within established cephalometric norms. **Methods:** A descriptive cross-sectional analysis was conducted using secondary cephalometric data from 96 post-treatment medical records. Incisor inclination was measured using U1–SN, U1–PP, L1–MP, and IMPA angles, while angulation was assessed for upper and lower central incisors. **Results:** The mean upper incisor angles were 106° (U1-SN) and 115° (U1-PP), and the lower incisor angles were 94° (L1-MP) and 96° (IMPA). The mean angulation of individual incisors was approximately 89–91° for both upper and lower central incisors. **Conclusion:** Pre-adjusted bracket systems used in the study effectively guide incisors toward favorable positioning within normal ranges, with minor variations such as the IMPA angle, supporting both functional and esthetic outcomes.This study took the initiative to describe both post-treatment upper and lower incisor position in Indonesian orthodontic patients.

[*] Corresponding Author
E-mail address: msk.adiwirya@gmail.com (Muhammad Sulaiman Kusumah Adiwirya)
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INTRODUCTION

Malocclusion is an irregular alignment of the teeth and/or an abnormal relationship between the dental arch and the teeth. The World Health Organization (WHO) identifies malocclusion as the third most common oral health issue globally.[1,2] In Indonesia, this condition is highly prevalent, affecting nearly 80% of the population, yet only about 0.7% receive orthodontic treatment.[3] Malocclusion cases need a comprehensive treatment plan to reach a normal, ideal occlusion which will give rise to normal teeth functions, including mastication, phonetics, as well as esthetics.[1,2] In orthodontics, the inclination and angulation of teeth are crucial components to achieve normal occlusion and evaluating the success of orthodontic treatment. Proper incisor inclination is essential for maintaining adequate lip support, achieving optimal overjet and overbite relationships, and enhancing smile esthetics. Excessive proclination may result in lip incompetence, gingival recession, and alveolar bone dehiscence, whereas retroclination can lead to deep overbite and compromised facial esthetics. Incisor angulation is critical for establishing correct interproximal contact and root alignment within the alveolar bone. Deviations from ideal angulation may cause occlusal interferences, uneven force distribution, periodontal stress, and an increased risk of post-treatment relapse.[4]

Researchers from Germany and Saudi Arabia have conducted studies on the description of tooth inclination and tooth angulation of their country.[5,6] One study in Indonesia described about upper incisor inclination through single measurement, U1-SN, collected from patients prior to orthodontic treatment.[7] However, there has been a notable absence of research on the inclination and angulation of teeth after orthodontic treatment in Indonesia. Local data on these aspects after fixed orthodontic treatment is essential, considering the potential influence of demographics and cultural variations to achieve an ideal dentition which is functionally and aesthetically accepted.

This study aims to describe the inclination and angulation of incisor in class I malocclusion patients after orthodontic treatment at the Universitas Indonesia Dental Hospital. Our study hypothesized that orthodontic treatment in Class I skeletal malocclusion patients results in incisor inclination and angulation values that fall within established cephalometric norms, reflecting favorable tooth positioning and successful treatment outcomes. We elaborated multiple lateral cephalometric and panoramic measurements as these examinations were compulsory records in orthodontic treatment.

The present study would complement the lack of data in Indonesia related to tooth inclination and angulation. Moreover, this study would take the lead in describing them in a more comprehensive approach, as we involved not only upper incisor but also lower incisor, that would be valuable for orthodontic clinical practice in attaining appropriate final incisor position at the end of the treatment.

MATERIALS AND METHOS

Study Sampling

Ethical approval was obtained from the Research Ethics Committee, Faculty of Dentistry, Universitas Indonesia (Approval No. 75/Ethical Approval/FKG UI/XI/2021). The research utilized secondary data derived from lateral and panoramic cephalometric radiographs collected at the Universitas Indonesia Dental Hospital. A total of 96 patients were included in this study, with the sample size determined using a 95% confidence interval standardized formula for non-probability sampling. The research subjects were selected according to the following criteria (1) had completed treatment at the Orthodontic Clinic from 2015 to 2021, (2) class I skeletal malocclusion (normal ANB relationship, 1-4^0) in the permanent dentition period, (3) undergone fixed orthodontic treatment without/with tooth extraction using pre-adjusted bracket system (MBT, Ormco, Glendora, CA, USA), (4) had lateral cephalometric and panoramic radiograph after treatment. The exclusion criteria are (1) incomplete medical record, lateral cephalometric radiograph, and panoramic radiograph with illegible landmarks, (2) patients with missing first upper central incisor and/or first lower central incisor. Data were collected from dental records including patient's name, gender, age, ethnicity, occupation, chief complaint, lateral cephalometric and panoramic radiographs after treatment.

Measurement

Researcher measured the inclination of the teeth with lateral cephalometric radiographs after fixed orthodontic treatment. Landmarks, reference lines, and measurements used in this study are described in Figure 2 and 3. The angular cephalometric measurements used in this study are summarized in Table 1.

Researcher assessed tooth angulation after fixed orthodontic treatment using panoramic radiographs. The landmarks, reference lines, and measurement methods employed in this study are illustrated in Figure 4.

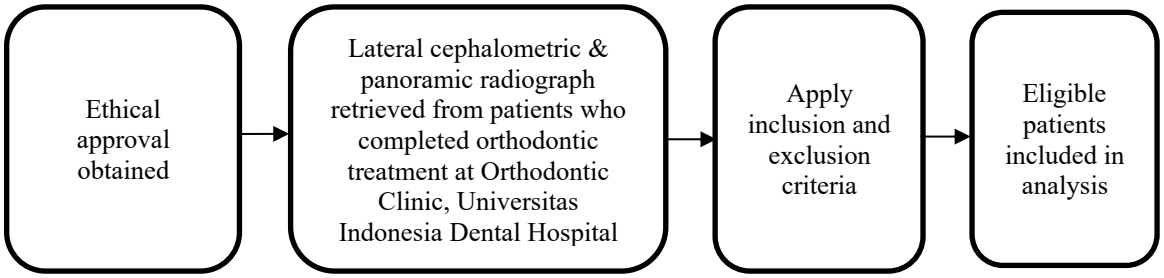
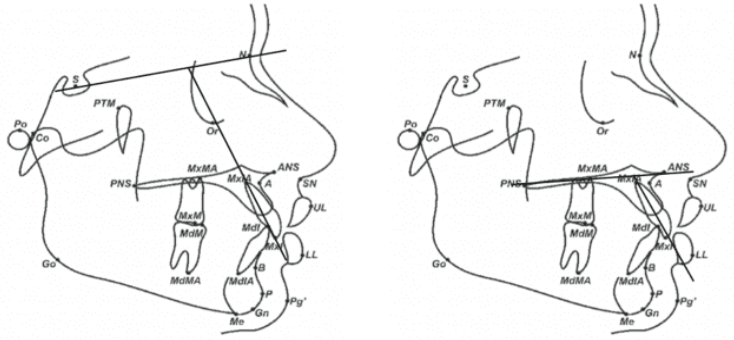
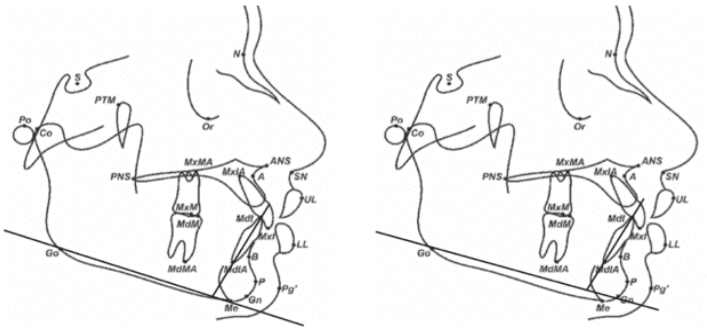


Figure 1. Flowchart of patient selection process



(a) (b)

Figure 2. Upper incisor inclination. (a) U1-SN, the angle between upper central incisor to the anterior cranial base; (b) U1-PP, the angle between upper central incisor to the palatal plane.



(a) (b)

Figure 3. Lower incisor inclination. (a) L1-MP, the angle between lower central incisor to the Menton-Gonion Line; (b) IMPA, the angle between lower central incisor to the mandibular plane.

Table 1. Angular cephalometric measurement used in this study

Variable	Definitions
SNA	The angle between the Sella–Nasion line and point A (subspinale)
SNB	The angle between the Sella–Nasion line and point B (supramentale)
ANB (°)	A cephalometric measurement used to determine the skeletal class of malocclusion, obtained by subtracting the SNB angle from the SNA angle
U1-SN (°)	The angle between upper central incisor to the anterior cranial base
U1-PP (°)	The angle between upper central incisor to the palatal plane
L1-MP (°)	The angle between lower central incisor to the Menton-Gonion line
IMPA (°)	The angle between lower central incisor to the mandibular plane

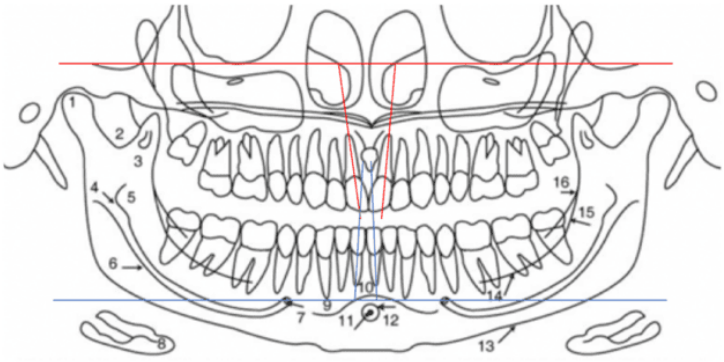


Figure 4. Incisor angulation. Red lines indicate upper incisor angulations to the infraorbital region in the maxilla. Blue lines indicate lower incisor angulations to the mental foramen in the mandible

Statistical Analysis

Researchers conducted a reliability test with a minimum sample of 10 samples (n> 10% of the total sample). Reliability tests were carried out intraobserver and interobserver, then the measurement results were tested with the Intraclass Correlation Coefficient (ICC) test in the Statistical Package for the Social Sciences (SPSS) statistical data program. All data were then recorded into raw data in Microsoft Excel and processed using the SPSS (Statistical Package for the Social Sciences) 25.0 Mac OS Multilingual (ISO Version). The mean, maximum, minimum, median, mode, and standard deviation values were then retrieved from data processing.

RESULTS

The preliminary reliability test confirmed that the measurements of ANB angle, inclination, and angulation of the first upper and lower central incisors using lateral cephalometric radiographs were reliable, as indicated by Intraclass Correlation Coefficient (ICC) values exceeding 0.80 for both intra-observer and inter-observer tests.A total of 96 medical records of class I malocclusion patients were obtained and recorded. Baseline characteristics of the patients are presented in Table 2.

Table 2. Characteristics of the 96 patients

	Category	Data
Gender	Male	20 (20,8%)
	Female	76 (79,2%)
Age	Adolescent(12-25years old)	67 (69,8%)
	Adult (26-45 years old)	28 (29,2%)
	Elderly (above 45 years old)	1 (1,0%)
Duration	1-12 months	10 (10,4%)
	13-24 months	58 (60,4%)
	25-36 months	28 (29,2%)
Extraction	Extraction	37 (38,6%)
	Non-extraction	59 (61,4%)

Table 3 describes the patient's malocclusion before fixed orthodontic treatment. Class I incisor relationship was found in the majority of the samples, representing 49.0%, while class III constituted the lowest percentage of the samples at 5.2%. Most of the first molar relationships were in class I (55.2%). The most common canine relationship was found in the combination category (having different right and left canine relationships) in 35 patients.

Table 3. Description of the patient's malocclusion

Variable	Frequency (%)
Incisor relationship	
Class I	47 (48,9%)
Class II	18 (18,8%)
Class III	5 (5,2%)
Cannot be determined	26 (27,1%)
Molar relationship	
Class I	53 (55,2%)
Class II	6 (6,3%)
Class III	5 (5,2%)
Combination	25 (26,0%)
Cannot be determined	7 (7,3%)
Canine relationship	
Class I	22 (22,9%)
Class II	26 (27,1%)
Class III	2 (2%)
Combination	35 (36,5%)
Cannot be determined	11 (11,5%)
Overjet	
N (2-4 mm)	60 (62,5%)
<N	20 (20,8%)
>N	16 (16,7%)
Overbite	
N (0 – 30%)	61 (63,6%)
<N	3 (3,1%)
>N	32 (33,3%)

Table 3 show average overjet distance of the research subjects was 2.88 ± 1.90 mm with the smallest

overjet value of 0 mm and the largest overjet value of 11 mm. The mean overbite of the study subjects was 2.89 ± 1.42 mm with the smallest overbite value of 0 mm and the largest overbite value of 7 mm.

Table 4. An overview of the patient's ANB angle

ANB	Frequency (%)
1°	16 (16,7%)
1,5°	3 (3,1%)
2°	24 (25,0%)
2,5°	2 (2,1%)
3°	19 (19,8%)
3,5°	1 (1,0%)
4°	31 (32,3%)

Table 4 shows the research subjects were primarily selected based on having a Class I skeletal malocclusion with an ANB angle within the specified range (1-4°), with the most common ANB angle being 4° among the patients studied.

Table 5. Descriptive statistics of anterior teeth inclinations in class I malocclusion patients after orthodontic treatment (2015-2021)

Incisor inclination n = 96	**Mean (SD)**	**Median (Min-Max)**
U1-SN	105,60° ± 5,80°	106° (90°-116°)
U1-PP	114,55° ± 6,21°	115° (97°-127°)
L1-MP	93,63° ± 7,94°	94° (78°-114°)
IMPA	96,40° ± 7,96°	96° (80°-116°)

Table 5 shows inclinations of the incisor after fixed orthodontic treatment in Class I skeletal malocclusion patients, using 4 parameter angles, namely the angles U1-SN and U1-PP for maxillary inclination and L1-MP and IMPA for mandibular inclination. The mean value of the U1-SN angle in the research subjects was 105.60° ± 5.80°, U1-PP angle was 114.55° ± 6.21°, L1-MP angle was 93.63° ± 7.94°, and IMPA angle was 96.40° ± 7.96°.

Table 6. Descriptive statistics of anterior teeth angulations in class i malocclusion patients after orthodontic treatment (2015-2021)

Incisor angulation n = 96	**Mean (SD)**	**Median (Min-Max)**
Upper right central incisor	89,03° ± 3,26°	89° (78°-96°)
Upper left central incisor	90,35° ± 3,07°	90° (82°-98°)
Lower left central incisor	89,28° ± 4,33°	89° (76°-103°)
Lower right central incisor	90,61° ± 5,04°	91° (75°-105°)

Table 6 shows the measurements of angulation of the maxillary and mandibular first incisors. The mean value of the upper right central incisor's angulation angle in the study subjects was 89.03° ± 3.26°, upper left central incisor is 90.35° ± 3.07°, lower left central incisor 89.28° ± 4.33°, and lower right central incisor is 90.61° ± 5.04°.

DISCUSSION

Andrews' six keys to normal occlusion are fundamental principles in orthodontics used to assess and achieve optimal tooth alignment and occlusion during treatment. These include molar relations, absence of rotation, good proximal contact, flat occlusal plane, tooth angulation, and tooth inclination. [8,9] Our study used U1-SN and U1-PP for maxillary incisor inclination and L1-MP and IMPA for mandibular incisors. As noted in previous literature, these angular parameters gauge whether incisors are positioned within desirable ranges.[5]

In our study, the mean U1-SN (105.60° ± 5.80) and U1-PP (114.55° ± 6.21) are comparable to values reported by Seidel *et al.* in a German population and align reasonably with Rakosi standards, although the U1-PP is slightly above Eastman's 109° ± 6° benchmark. [5] The elevated value might reflect ethnic/craniofacial differences in our Indonesian (Mongoloid) cohort, who may present with greater dentoalveolar protrusion and shorter cranial bases.[10] Since Indonesians belong to the Mongoloid race, the study's findings reflect these distinctive traits, with most patients showing dentoalveolar bimaxillary protrusion, resulting in a more protruded position of the first incisor.

Ellis *et al.* (1986) stated in their research that maxilla tilting could affect the measurement of the U1-SN angle. Ellis also pointed out that the shape of the palatal plane can vary, which will affect the results of the U1-PP angle measurement. The palatal plane taken on lateral cephalometric radiographs is often not in the form of a straight line causes inaccurate measurements of the palatal plane, which affects the measurement of the U1-PP angle. Therefore, good-quality radiographs are needed to obtain accurate measurement results.[11] In addition, the thickness of the alveolar bone affects the movement of orthodontic devices. Guo R *et al.* (2015), stated that alveolar bone height and thickness, especially at the cervical level, decreased during both labial and lingual movement of anterior teeth.[12] Research has shown that labial alveolar bone thickness correlates with buccolingual maxillary incisor angulation, as assessed through CBCT. This suggests that variations in bone structure can influence incisor positioning, which is essential for planning and evaluating orthodontic treatments.[13,14]

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According to Ellis et al. (1986), the L1-MP and IMPA angles provide precise measurements of the mandibular first incisor's inclination, as the position of the mandibular first incisor is closely associated with the mandibular bone.[11] The mean L1-MP (93.63° ± 7.94) and IMPA (96.40° ± 7.96) exceed typical normative values (Tweed's IMPA ~90° ± 5°) and again likely reflect this protrusive tendency.[10] Correlation analyses stated that patients with inclined incisors after treatment (IMPA > 95°) showed changes in clinical crown height and gingival scallop compared to patients with ortho-axial inclination of the lower incisors (IMPA < 95°).[5]

After orthodontic treatment, the angulation of the upper and lower incisors tends to be relatively upright. Factors influencing tooth angulation include the type of bracket used, its placement, and the movements of the teeth. Particularly with pre-adjusted bracket systems, the position of the bracket affects angulation, torque, and rotation of the teeth. Incorrect bracket placement can lead to poor tooth angulation, necessitating more adjustments and potentially extending treatment time or resulting in suboptimal final occlusion. Bracket placement can be challenging due to patient malocclusion or operator errors, so it is crucial for the operator to place the brackets accurately from the start of treatment.[15,16,17] Pour RD *et al.* (2023) identified the initial tooth angulation as the primary factor influencing treatment outcomes. They also highlighted the importance of taking into account the patient's vertical skeletal pattern and whether the treatment plan included extractions.[15]

Effective orthodontic treatment relies on accurate diagnosis and a carefully structured treatment plan to achieve optimal outcomes. Recent developments in artificial intelligence, such as the CephGPT-4 system, incorporate multimodal inputs—including cephalometric radiographs and patient information—to enhance orthodontic assessment. These AI-driven approaches can automate the evaluation of incisor inclination and angulation, providing faster and potentially more precise post-treatment analyses compared to conventional cephalometric methods.[18]

From a clinical viewpoint, our results support the feasibility of achieving favourable incisor inclination/angulation in skeletal Class I malocclusion patients using conventional treatment mechanics. However, the emerging evidence from CBCT/AI studies indicates that success is not just a matter of tooth angulation, but also of alveolar bone morphology, skeletal divergence, and positional context of root and bone anatomy. Therefore, clinicians should consider incorporating advanced imaging (CBCT) and potentially AI tools into treatment planning — particularly for patients with complex skeletal patterns or borderline alveolar support. Future research might investigate how post-treatment incisor positions correlate with long-term stability, periodontal health, and alveolar bone changes using 3D and AI-driven methods.

A limitation of this study is the timing of the post-treatment radiographs. Lateral cephalometric and panoramic radiographs may have been taken just before debonding while the patient was still wearing a fixed orthodontic appliance, rather than at the actual end of treatment. This timing could allow for adjustments that might affect the patient's inclinations and angulations, not accurately reflecting the final treatment outcome. Another limitation is the difficulty in getting research subjects who meet the inclusion criteria, as not all orthodontic patients take post-treatment radiographs at the same hospital. Furthermore, this study was limited to the use of two-dimensional imaging modalities—specifically cephalometric and panoramic radiographs—which are routinely taken as part lateral of standard orthodontic records. Although three-dimensional imaging such as CBCT could provide more accurate assessments, it is not considered the gold standard for routine orthodontic evaluation and is only indicated in specific clinical cases; therefore, CBCT data were not available for all patients.

CONCLUSIONS

The study indicates that, in Class I malocclusion patients treated with fixed orthodontic appliances at the Universitas Indonesia Dental Hospital, the average anterior tooth inclination generally falls within normal ranges, except for the IMPA angle. Incisor angulation was relatively upright and parallel, reflecting effective achievement of planned tooth positioning. These findings suggest that the pre-adjusted bracket system can produce incisor inclination and angulation outcomes consistent with clinical expectations.

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CONFLICT OF INTEREST

The authors report no conflict of interest.

REFERENCES

1. FDI World Dental Federation. Malocclusion in orthodontics and oral health. *Int Dent J*. 2020.
2. Alogaibi YA, Murshid ZA, Alsulimani FF, Linjawi AI, Almotairi M, Alghamdi M, et al. Prevalence of malocclusion and orthodontic treatment needs among young adults in Jeddah city. *J Orthod Sci*. 2020;9(1):3-10

3. Badan Penelitian dan Pengembangan Kesehatan RI. Hasil Riset Kesehatan Dasar (RISKESDAS). 2018. p. 94.
4. Sangalli L, Dalessandri D, Bonetti S, Mandelli G, Visconti L, Savoldi F. Proposed parameters of optimal central incisor positioning in orthodontic treatment planning: A systematic review. *Korean J Orthod*. 2022;52(1):53-65.
5. Seidel CL, Baumert U, Ost F, Sabbagh H, Wichelhaus A. Inclination changes in incisors during orthodontic treatment with passive self-ligating brackets. *J Clin Med*. 2025;14(10):3370.
6. Aloufi NM, Al Qazlan FS, Alfawzan AA. Mandibular incisors angulation and position among various vertical facial patterns: An artificial intelligence-based cephalometric study. *Bioinformation*. 2025;28;21(2):113-115.
7. Maringka SMF, Buntara MJH. Gambaran inklinasi insisivus sentral maksila pada pasien ortodonti usia 18-25 tahun berdasarkan analisis sudut U1-SN. *Jurnal Kedokteran Gigi Terpadu*. 2024;6(1):87-90.
8. Andrews Foundation. The six elements orthodontic philosophy: goals, diagnosis, classification, and treatment.2025.https://www.andrewsfoundation.org/ publications.html
9. Alqahtani H. Trends and protocols in orthodontic finishing: a cross-sectional study. *J Int Clin Dent Res Organ*. 2025;17(1):69–77.
10. Peter E, Monisha J. Composite lateral cephalometric norms – a pooled estimate of 137 Indian studies. *J Contemp Orthod*. 2024;8(2):156-71.
11. Ellis E, McNamara JA. Cephalometric evaluation of incisor position. *Angle Orthod*. 1986;56(4):324–44.
12. Guo R, Zhang L, Hu M, Huang Y, Li W. Alveolar bone changes in maxillary and mandibular anterior teeth during orthodontic treatment: A systematic review and meta-analysis. *Orthod Craniofac Res*. 2021;24(2):165-179.
13. Alqhtani NR, Alenazi A, Alqahtani AS, Gufran K, Robaian A, Alqahtani AM, Aldossary SF, Aldossry MF. Labial alveolar bone thickness and its correlation with buccolingual maxillary incisors angulation: a CBCT based study. *Eur Rev Med Pharmacol Sc*i. 2022 Jul;26(13):4625-4633. doi: 10.26355/eurrev_202207_29184.
14. Dalaie K, Hajimiresmail YS, Safi Y, Baghban AA, Behnaz M, Rafsanjan KT. Correlation of alveolar bone thickness and central incisor inclination in skeletal Class I and II malocclusions with different vertical skeletal patterns: A CBCT study. *Am J Orthod Dentofacial Orthop*. 2023;164(4):537-44. doi:10.1016/j.ajodo.2023.02.021.
15. Pour RD, Papageorgiou SN, Safi S, Eble OS, Jäger A, Gölz L. Clinical implementation of axial angulation of incisors in the course of routine fixed appliance treatment - a retrospective cohort study. *Clin Oral Investig*. 2023;27(2):659-669.
16. Littlewood SJ, Mitchell L. An introduction to orthodontics. 5th edition. Oxford, United Kingdom: Oxford University Press. 2019. p. 236.
17. Cobourne MT, DiBiase AT. Handbook of orthodontics. 3rd edition. Elsevier Science. 2024.
18. Ma, L., Han, J., Wang, Z., & Zhang, D. (2023). CephGPT-4: An interactive multimodal cephalometric measurement and diagnostic system with visual large language model. *arXiv*. https://doi.org/10.48550/arXiv.2307.07518