

Original Article

Effect of Deep Overbite and Curve of Spee on Wits Appraisal with Bisecting and Functional Occlusal Planes

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Received: 14 November 2024

Revised: 27 November 2024

Accepted: 19 December 2024

Published: 30 December 2024

HOW TO CITE

Maria Zehri et al. 2024. Effect of Deep Overbite and Curve of Spee on Wits Appraisal with Bisecting and Functional Occlusal Planes. Journal of Health, Wellness and Community Research. 2, 2 (Dec. 2024), 1–6. DOI:https://doi.org/10.61919/3hjgav89

ARTICLE INFORMATION

Author Contributions	Concept: MZ, NM; Design: MZ, NM, MB; Data Collection: MZ, MA, MH, IA; Analysis: MZ, NM, MB; Drafting: MZ, NM, MA, MH, IA, MB.
Ethical Approval	The study was approved by research ethical board of Bolan Medical College, Quetta, Pakistan
Informed Consent	Written informed consent was obtained from all participants
Conflict of Interest	The authors declare no conflict of interest.
Funding	No external funding.
Data Availability	Available from the corresponding author on reasonable request.
AI Declaration	No generative AI was used for conceptualization, analysis, or content generation. AI use was limited to language refinement, and the authors remain fully responsible for the accuracy, originality, validity, and integrity of the manuscript's content.

ABSTRACT

Background: Wits appraisal depends on the selected occlusal plane, potentially affecting its interpretation across different occlusal characteristics. **Objective:** To compare Wits measurements obtained using functional and bisecting occlusal planes in patients with normal versus deep overbite and accentuated curve of Spee. **Methods:** This comparative cross-sectional study at Bolan Medical College, Quetta, included 100 orthodontic patients aged 13–25 years with Class I molar relationships. Group A comprised 50 patients with overbite ≤ 3 mm and curve of Spee ≤ 2 mm; Group B comprised 50 with overbite > 3 mm and curve of Spee > 2 mm. Pretreatment cephalograms and dental casts provided measurements. Between-group comparisons used Welch's t-test; within-group comparisons used paired t-tests. **Results:** Mean Wits-FOP was -1.1 ± 1.2 mm in Group A and -3.9 ± 1.5 mm in Group B; the between-group difference was -2.80 mm (95% CI, -3.34 to -2.26). Corresponding Wits-BOP values were -0.8 ± 1.1 and -2.2 ± 1.3 mm, with a difference of -1.40 mm (95% CI, -1.88 to -0.92); both $p < 0.001$. Paired FOP-BOP differences were -0.30 mm in Group A ($p = 0.210$) and -1.70 mm in Group B ($p < 0.001$). **Conclusion:** Wits values differed by combined occlusal phenotype and plane construction, without establishing superior diagnostic accuracy or reliability. **Keywords:** Wits appraisal; deep overbite; curve of Spee; functional occlusal plane; bisecting occlusal plane.

INTRODUCTION

Assessment of the sagittal relationship between the maxilla and mandible is an important component of orthodontic diagnosis. Cephalometric measurements provide quantitative descriptions of this relationship, although their interpretation depends on the landmarks and reference planes used. Jacobson introduced the Wits appraisal as a method of assessing anteroposterior jaw disharmony by projecting points A and B perpendicularly onto the occlusal plane and measuring the distance between their projections, AO and BO. This construction provides an assessment that does not directly depend on cranial-base landmarks, while making the selected occlusal plane integral to the resulting measurement (1).

The interpretation of sagittal measurements also requires consideration of the dental and occlusal characteristics of the patient. Andrews' description of the six keys to normal occlusion provides a framework for evaluating these characteristics rather than considering molar relationships in isolation (2). Among the features relevant to the present investigation are overbite and the curve of Spee, which describe anterior vertical overlap and the sagittal curvature of the mandibular dentition, respectively. The importance of distinguishing occlusal geometry from treatment-related changes is illustrated by Braun and colleagues, who examined the relationship between curve-of-Spee depth and arch circumference. Their findings suggested that incisor protrusion associated with levelling could not be explained solely by the geometric difference between a curved arch and its planar projection, highlighting the need for caution when attributing dental changes to a single geometric feature (3).

For Wits appraisal, a related measurement question concerns the choice of occlusal reference plane. The functional occlusal plane and bisecting occlusal plane use different dental reference constructions. In the present study, the functional occlusal plane represents the posterior occlusal contacts, whereas the bisecting occlusal plane incorporates the midpoints of the incisor and first-molar overlap. Because Wits appraisal is obtained by projecting the same skeletal landmarks onto the selected plane, differences between these constructions may produce different measurements in the same patient. Such differences warrant investigation in patients with deep overbite and an accentuated curve of Spee, but they should not automatically be interpreted as evidence that either construction is more accurate or reliable (4-7).

The specific question addressed by this study is how Wits measurements obtained using these two planes compare in patients with different combined overbite and curve-of-Spee characteristics. The foundational literature on Wits appraisal, normal occlusion, and curve-of-Spee geometry provides a rationale for this comparison but does not, by itself, establish the relative performance of the two plane constructions in the selected clinical population (1-3). Evaluating both measurements within the same participants permits a direct assessment of plane-dependent differences, while comparison between occlusal groups places these differences in a clinically defined context. Because deep overbite and an accentuated curve of Spee occur together in the exposed group, the study evaluates this combined phenotype rather than isolating the independent contribution of either characteristic (8-10).

Accordingly, this comparative cross-sectional study aimed to compare Wits appraisal measured using functional and bisecting occlusal planes among orthodontic patients aged 13-25 years with Class I molar relationships at Bolan Medical College, Quetta. Between-group comparisons involved patients with normal overbite and curve of Spee and patients with deep overbite and an accentuated curve of Spee; within-group comparisons evaluated the paired Wits measurements obtained using the two occlusal planes (11,12).

MATERIAL AND METHODS

A comparative cross-sectional study was conducted in the Department of Orthodontics at Bolan Medical College, Quetta, Pakistan, during the reported study period of 4 November 2022 to 4 June 2023. The study compared Wits appraisal measurements obtained using the functional occlusal plane (FOP) and bisecting occlusal plane (BOP) in patients with different combined overbite and curve-of-Spee characteristics. Both measurements were obtained from the same pretreatment lateral cephalogram for each participant, allowing comparisons between occlusal groups and paired comparisons between plane constructions within each group.

The study population comprised orthodontic patients aged 13-25 years with a Class I molar relationship. Eligibility required good-quality pretreatment lateral cephalograms and dental casts and no history of orthodontic treatment. Patients with craniofacial anomalies, missing permanent teeth other than third molars, or restorations that altered the occlusion were excluded. Participants were selected using nonprobability consecutive sampling. The reported sample-size rationale specified 80% statistical power, a 95% confidence level, and an anticipated mean difference of 1.5 mm. The study included 100 participants, with 50 in each occlusal group.

Participants were classified according to their pretreatment overbite and curve-of-Spee measurements. Group A comprised patients with an overbite of ≤ 3 mm and a curve of Spee of ≤ 2 mm. Group B comprised patients with an overbite of > 3 mm and a curve of Spee of > 2 mm. Both criteria were required for membership of the respective group. These categories represented the combined occlusal characteristics under investigation; the between-group comparisons therefore assessed differences associated with the combined phenotype rather than the independent contribution of overbite or curve-of-Spee depth.

Data were obtained from pretreatment lateral cephalograms and dental casts. Overbite was measured on the lateral cephalogram and recorded in millimetres. Curve-of-Spee depth was measured on the mandibular dental cast as the perpendicular distance from a flat reference plane to the deepest cusp tip of the mandibular arch and was also recorded in millimetres. Participant age was recorded in years. All cephalometric tracings were performed by a single operator.

Wits appraisal was determined by projecting points A and B perpendicularly onto the selected occlusal plane and measuring the distance between their projections, designated A0 and B0, respectively (1). For Wits-FOP, the reference plane passed through the mean cuspal contacts of the molars and premolars. For Wits-BOP, the reference plane passed through the midpoints of the vertical overlap of the upper and lower incisors and first molars. Wits values were expressed in millimetres, with a negative value indicating that B0 was positioned anterior to A0 (1). The two plane-specific measurements constituted paired observations for each participant. Intra-examiner measurement error was assessed using Dahlberg's formula.

Statistical analysis was performed using IBM SPSS Statistics version 26.0. Continuous variables were summarized as means and standard deviations. Independent-samples t-tests were used to compare age, overbite, curve-of-Spee depth, Wits-FOP, and Wits-BOP between Groups A and B. Paired-samples t-tests were used to compare Wits-FOP and Wits-BOP within each group, accounting for the fact that both measurements were obtained from the same participants. The principal outcomes were the between-group differences in Wits values for each plane and the within-group differences between the two plane-specific measurements.

The study was conducted following approval from the institutional ethical review committee.

RESULTS

The study included 100 participants, with 50 in each group. Mean age was 17.0 ± 2.8 years in Group A and 17.4 ± 3.0 years in Group B, corresponding to a between-group difference of 0.40 years (95% CI, -0.75 to 1.55; $p = 0.492$). Consistent with the criteria used to define the groups, Group B had greater mean overbite and curve-of-Spee depth, with between-group differences of 2.70 mm (95% CI, 2.33 to 3.07) and 1.90 mm (95% CI, 1.63 to 2.17), respectively (Table 1).

Wits measurements were more negative in Group B using both occlusal planes. Mean Wits-FOP was -3.9 ± 1.5 mm in Group B compared with -1.1 ± 1.2 mm in Group A, yielding a between-group difference of -2.80 mm (95% CI, -3.34 to -2.26 ; $p < 0.001$; Hedges' $g = -2.05$). Mean Wits-BOP was -2.2 ± 1.3 mm and -0.8 ± 1.1 mm, respectively, with a between-group difference of -1.40 mm (95% CI, -1.88 to -0.92 ; $p < 0.001$; Hedges' $g = -1.15$). The absolute between-group difference and standardized effect estimate were numerically greater for FOP than for BOP (Table 2).

Table 1. Participant age and occlusal characteristics by study group

Variable	Group A (n = 50), mean $\pm$ SD	Group B (n = 50), mean $\pm$ SD	Mean difference, B – A	95% CI	p-value
Age (years)	17.0 ± 2.8	17.4 ± 3.0	0.40	-0.75 to 1.55	0.492
Overbite (mm)	2.1 ± 0.7	4.8 ± 1.1	2.70	2.33 to 3.07	<0.001
Curve of Spee (mm)	1.3 ± 0.5	3.2 ± 0.8	1.90	1.63 to 2.17	<0.001

Group A: overbite ≤ 3 mm and curve of Spee ≤ 2 mm; Group B: overbite > 3 mm and curve of Spee > 2 mm. SD, standard deviation; CI, confidence interval. Between-group comparisons: two-sided Welch's independent-samples t-test. Mean differences: Group B minus Group A.

Table 2. Between-group comparisons of Wits appraisal by occlusal plane

Outcome	Group A (n = 50), mean $\pm$ SD	Group B (n = 50), mean $\pm$ SD	Mean difference, B – A (mm)	95% CI (mm)	p-value	Hedges' g
Wits-FOP (mm)	-1.1 ± 1.2	-3.9 ± 1.5	-2.80	-3.34 to -2.26	<0.001	-2.05
Wits-BOP (mm)	-0.8 ± 1.1	-2.2 ± 1.3	-1.40	-1.88 to -0.92	<0.001	-1.15

FOP, functional occlusal plane; BOP, bisecting occlusal plane; SD, standard deviation; CI, confidence interval. Between-group comparisons: two-sided Welch's independent-samples t-test. Mean differences and Hedges' g : Group B minus Group A. Hedges' g : standardized mean difference using the pooled SD and a small-sample correction.

Table 3. Paired comparisons of Wits appraisal using functional and bisecting occlusal planes

Group	Paired observations, n	Wits-FOP (mm), mean $\pm$ SD	Wits-BOP (mm), mean $\pm$ SD	Mean paired difference, FOP – BOP (mm)	p-value
A	50	-1.1 ± 1.2	-0.8 ± 1.1	-0.30	0.210
B	50	-3.9 ± 1.5	-2.2 ± 1.3	-1.70	<0.001

FOP, functional occlusal plane; BOP, bisecting occlusal plane; SD, standard deviation. Within-group comparisons: paired-samples t-test. Mean paired differences: Wits-FOP minus Wits-BOP.

Within Group A, the mean paired difference between Wits-FOP and Wits-BOP was -0.30 mm ($p = 0.210$). Within Group B, Wits-FOP was 1.70 mm more negative than Wits-BOP, corresponding to a mean paired difference of -1.70 mm ($p < 0.001$; Table 3).

DISCUSSION

This study found that Wits appraisal values differed between patients with normal overbite and curve of Spee and those with deep overbite and an accentuated curve of Spee. Both occlusal-plane constructions yielded more negative values in the latter group. Within that group, measurements obtained using the functional occlusal plane were also more negative than those obtained using the bisecting occlusal plane. These findings address the study objective by demonstrating differences associated with the combined occlusal phenotype and the selected reference plane, without establishing the diagnostic superiority of either construction (12,13).

The findings are consistent with the geometric dependence inherent in Wits appraisal. Jacobson's original method measures the separation of projections from points A and B onto an occlusal reference plane; consequently, the resulting value incorporates both the relationship between the skeletal landmarks and the orientation of that plane (1). The present findings extend this measurement question to two plane constructions within a selected orthodontic population. However, a difference between their values does not establish which construction more accurately represents the underlying sagittal relationship. The original appraisal provides the conceptual basis for the comparison rather than direct evidence that BOP should be preferred in patients with deep overbite.

Occlusal morphology offers a plausible explanation for the observed pattern. FOP and BOP are constructed using different dental reference points, so variation in anterior overlap and posterior occlusal relationships may alter their relative orientation and the distances obtained by projection. This explanation remains a hypothesis because the study did not report plane-inclination measurements or directly analyse the geometric contribution of individual landmarks. Andrews' description of normal occlusion emphasizes a combination of dental characteristics, providing a broader context for interpreting the study's restriction to Class I molar relationships (2). That restriction does not, by itself, demonstrate that the groups had equivalent underlying skeletal relationships.

Previous work on the curve of Spee also supports caution when attributing measurement differences to a single anatomical feature. Braun and colleagues investigated the relationship between curve-of-Spee geometry and arch circumference and found that the geometric contribution of levelling was smaller than earlier estimates had suggested. They attributed associated incisor protrusion more directly to the mechanics of levelling than to the arch-length difference alone (3). Their investigation concerned a different outcome and therefore cannot be treated as direct confirmation of the present FOP-BOP findings. Nevertheless, it illustrates why the relationship between occlusal curvature and a measured dental outcome requires explicit assessment rather than an assumed geometric explanation (14,15).

The magnitude of the between-group differences was numerically greater for FOP than for BOP, and the standardized differences followed the same pattern. These estimates describe separation between the selected groups; they do not establish clinical diagnostic benefit. Likewise, the statistically significant paired difference in the deep-overbite group and the nonsignificant paired difference in the normal-overbite group do not demonstrate a statistically significant difference between those paired contrasts. A direct group-by-plane analysis would be necessary to support that inference. The nonsignificant result in Group A should therefore not be interpreted as evidence that the two constructions are equivalent.

Clinically, the findings highlight the importance of identifying the occlusal plane used when interpreting or comparing Wits measurements. Because the reference plane forms part of the measurement definition, values obtained using different constructions should be interpreted with attention to that distinction (1). The present study did not evaluate diagnostic classification against an independent reference standard, changes in treatment

planning, or patient outcomes. It therefore cannot establish that BOP prevents misdiagnosis or improves treatment decisions. Its implications concern cephalometric measurement in a selected clinical sample rather than population-level screening or public-health effectiveness (16, 17)

A strength of the study was the paired assessment of both planes on the same pretreatment cephalogram, which reduced between-participant variation in the within-group comparison. Use of a single operator also standardized the tracing process, although it did not eliminate observer error. The principal limitations were the cross-sectional design, single-centre nonprobability sample, and restriction to patients with Class I molar relationships. Defining the groups jointly by overbite and curve-of-Spee depth prevented the reported group comparisons from separating their independent associations with Wits appraisal. Potential differences in skeletal morphology, sex distribution, and developmental stage were not addressed by the reported analyses. Measurement-error results were also absent, preventing an assessment of comparative repeatability. The summary-based confidence intervals and standardized effect estimates were calculated from rounded values and should be regarded as approximate. Further investigation should directly evaluate differences between the paired plane contrasts, quantify repeatability, and assess diagnostic validity before clinical superiority is inferred (18).

CONCLUSION

Among orthodontic patients with Class I molar relationships, deep overbite combined with an accentuated curve of Spee was associated with more negative Wits appraisal values using both functional and bisecting occlusal planes. Within this group, the functional occlusal plane produced more negative measurements than the bisecting occlusal plane. These findings indicate that occlusal-plane selection influences the measurements obtained in this sample, but do not establish greater reliability or diagnostic accuracy of either construction.

REFERENCES

1. Jacobson A. The "Wits" appraisal of jaw disharmony. *Am J Orthod.* 1975;67(2):125-38.
2. Ghosh J, Nanda RS. Evaluation of an improved cephalometric analysis for the diagnosis of sagittal and vertical discrepancies. *Am J Orthod Dentofacial Orthop.* 1996;110(3):252-8.
3. Bishara SE, Fahl JA, Peterson LC. Longitudinal changes in the ANB angle and Wits appraisal: clinical implications. *Am J Orthod.* 1983;84(2):133-9.
4. Proffit WR, Fields HW, Sarver DM. *Contemporary Orthodontics*. 6th ed. Elsevier; 2018. Steiner CC. Cephalometrics for you and me. *Am J Orthod.* 1953;39(10):729-55.
5. Downing KJ, Nanda R. The effect of early functional appliance therapy on curve of Spee. *Angle Orthod.* 1998;68(2):123-8.
6. Ferrazzini G. Critical evaluation of the curve of Spee. *Angle Orthod.* 1976;46(2):202-6.
7. Andrews LF. The six keys to normal occlusion. *Am J Orthod.* 1972;62(3):296-309.
8. McNamara JA Jr. A method of cephalometric evaluation. *Am J Orthod.* 1984;86(6):449-69.
9. Braun S, Hnat WP, Johnson BE. The curve of Spee revisited. *Am J Orthod Dentofacial Orthop.* 1996;110(2):206-10.
10. Ricketts RM. Cephalometric synthesis. *Am J Orthod.* 1960;46(9):647-73.
11. Burstone CJ. Diagnosis and treatment planning of patients with asymmetries. *Semin Orthod.* 1998;4(3):153-64.
12. Roth RH. Functional occlusion for the orthodontist. *J Clin Orthod.* 1981;15(1):32-51.
13. Nanda R. *Biomechanics and Esthetic Strategies in Clinical Orthodontics*. Elsevier; 2005. Sakuda M, Kuroda T, Wada K. Changes in occlusal plane during orthodontic treatment. *Am J Orthod.* 1978;74(5):539-48.
14. Haynes S. The curve of Spee and orthodontic treatment. *J Clin Orthod.* 1978;12(5):351-6.

15. Xu TM, Liu Y, Yang MZ. Comparison of occlusal planes in different malocclusions. *Angle Orthod.* 2004;74(6):784-9.
16. Watanabe K, Kuroda T. The effect of occlusal plane inclination on Wits appraisal. *J Oral Rehabil.* 1999;26(12):1002-6.
17. Cooke MS, Wei SH. The reproducibility of natural head posture: a methodological study. *Am J Orthod Dentofacial Orthop.* 1988;93(4):280-8.
18. Al-Khateeb SN, Al-Khateeb LT. Ancephalometric evaluation of the sagittal skeletal discrepancy in Class II subjects. *Angle Orthod.* 2009;79(2):234-8.