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COMPARATIVE RELIABILITY OF THE TAU ANGLE VERSUS YEN, BETA, W, AND ANB ANGLES IN SAGITTAL SKELETAL ASSESSMENT USING FACAD SOFTWARE

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INTRODUCTION

Accurate assessment of sagittal skeletal relationships plays a pivotal role in orthodontic diagnosis and treatment planning. The ANB angle, introduced by Cecil C. Steiner, remains one of the most widely used parameters; however, it is influenced by cranial base length and jaw rotations. Similarly, the WITS appraisal proposed by Alexander Jacobson depends on the occlusal plane, limiting its reliability.

To overcome these limitations, alternative angular parameters such as the Beta angle, Yen angle, and W angle have been introduced. While these parameters attempt to reduce dependency on cranial landmarks, variability in landmark identification and geometric construction persists.

The TAU angle has recently been proposed as a novel parameter aimed at improving diagnostic reliability. However, its comparative performance with established sagittal indicators remains inadequately explored. Therefore, the present study aimed to evaluate the reliability, agreement, and diagnostic validity of the TAU angle using FACAD software.

MATERIALS AND METHODS

Study Design

A cross-sectional analytical study.

Sample

- Sample size: **40 subjects**
- Age range: **15–41 years**
- Inclusion criteria:
  - Good quality lateral cephalograms
  - No prior orthodontic treatment

- **Exclusion criteria**
  - Craniofacial anomalies
  - Distorted radiographs

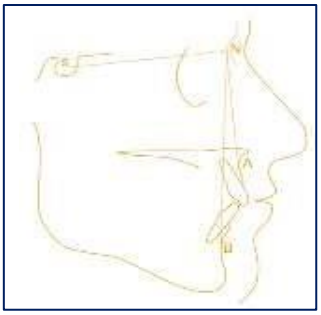
Data Collection

Cephalometric analysis was performed using **FACAD software**. The following parameters were recorded:

- ANB angle
- WITS appraisal
- Beta angle
- Yen angle
- W angle
- TAU angle

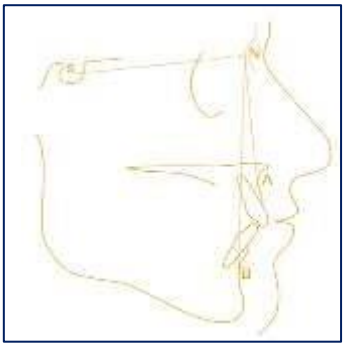
- **ANB ANGLE**
- Introduced by: Richard A. Riedel1 (1952), later Cecil C Steiner in 1953 used this analysis. It is the difference between the SNA angle and the SNB angle. It evaluates the sagittal relationship between the maxilla and mandible. This has been the most followed method of measuring sagittal discrepancy, but it has a major disadvantage in that differences were found between the interpretation of this angle and the actual discrepancy between the maxillary and mandibular bases. It is also affected by the slightest of changes in the point Nasion, length of the cranial base, and anterior face height. ANB increases clockwise and decreases with counterclockwise rotation of the jaws.[2]
- In Binder's study every 5 mm of anterior displacement of Nasion horizontally, the ANB angle reduces by 2.5. ° A 5 mm upward displacement of Nasion decreases the ANB angle by 0.5°, and a 5

mm downward displacement increases the ANB angle by 1°

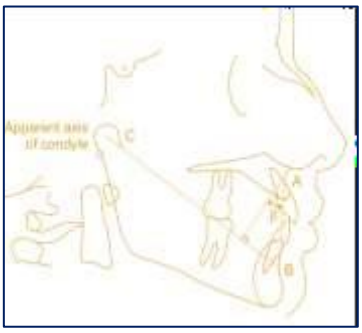


- **Wit's Appraisal of Jaw Disharmony**
- Introduced by: Alex Jacobson (1975). Overcomes the shortcomings of the ANB angle.

The mean value for Wits	
Skeletal Class l pattern:	BO coincides with AO in females, BO is 1mm ahead of AO in males°,
Class II:	BO was positioned well behind point AO (positive reading),
Class III:	BO is positioned ahead of point AO (negative reading).



- **Beta angle**
- Introduced by Chong Yo Baik and Maria Ververidou (2004)



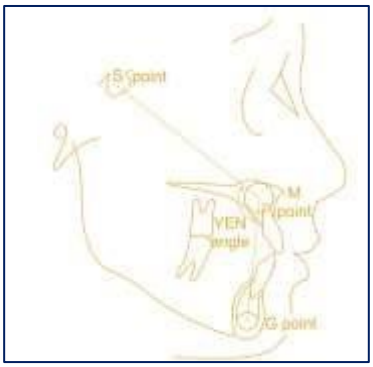
- The beta angle is formed between the A-B line and Point A, perpendicular to the C-B line. This angle indicates the severity and the type of skeletal dysplasia in the sagittal dimension. The points used here are stable and reflect true sagittal changes during treatment; hence, they can be used to check the progress of the treatment or evaluate changes that have occurred during treatment or at the end. It shows true sagittal dysplasia as it does not change with forward or backward rotation of the mandible.[4]

- Perpendiculars from Point A and B on the maxilla and mandible, respectively, are drawn onto the occlusal plane. The points of contact are labeled AO and BO, respectively. The distance between BO and AO is measured. According to Jacobson, in a skeletal Class I relationship, in females, AO and BO should coincide; in males, BO is ahead of AO by 1 mm in males. It changes with orthodontic treatment but does not change significantly with age (after permanent teeth have erupted completely) if untreated.[3]

Mean value for Beta angle	
Skeletal Class l pattern:	**27°-34°,**
Class II:	**< 27°,**
Class III:	**>34°.**

YEN ANGLE

Mean value for the yen angle	
Skeletal Class l pattern:	**117°-123°,**
Class II:	**< 117°,**
Class III:	**>123°.**



- Introduced by: Praveen Kumar Neela et al (2009). This angle was developed in the Yenepoya Dental College, Mangalore, Karnataka, India.
- Reference points used are S (Sella), M (midpoint of premaxilla), and G (center of the largest circle that is tangent to the internal inferior, anterior, and posterior surface of mandibular symphysis). G and M points were first used by Nanda and Merrill.
- It uses more stable landmarks and eliminates the

difficulty in locating Points A and B, the functional occlusal plane, and the condylar axis. These landmarks are found to be more stable, i.e., have no significant growth-related changes. Rotation of the jaw can give a false positive or a false negative result.[5]

- **WANGLE**
- Introduced by Wasundra A. Bhad et al (2011)
- The W angle is measured between the perpendicular line from Point M to the S-G line and the M-G line. Similar to the beta angle, the w angle also shows true sagittal dysplasia by not being affected by the clockwise and counterclockwise rotation of the mandible.

Mean value for the w angle	
Skeletal Class l pattern:	**51°-56°,**
Class II:	**< 51°,**
Class III:	**>56°.**

Tau angle

- Introduced by: ***Gupta P, Singh N, Tripathi T, et al (2020)***
- Tau angle is measured between the two lines connecting T and G points and M and G points.
- Advantage: Tau angle reflects true saggital maxillomandibular discrepancy and is not affected by growth rotations and head positioning

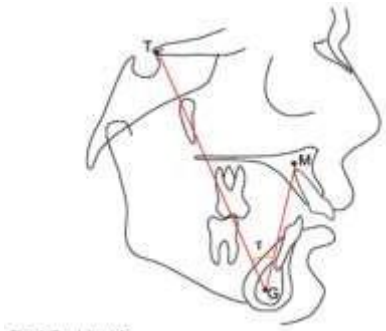
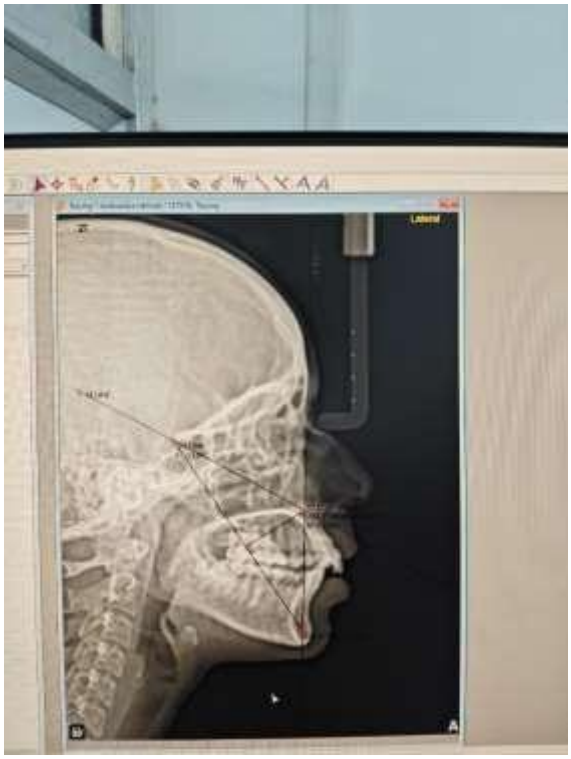


Fig. 1: Tau (τ) angle

Mean value for Tau angle	
Class I	**28.5° – 34.25°**
CLASS II	**>34.25°**
CLASS III	**<28.5°**

- **FACAD SOFTWARE ANALYSIS**



- **DATA OBTAINED**

Name	Age	Sex	OP D No.	SNA Angle	SNB Angle	ANB	WITS	Facial	Beta	Naso labial	Yen	w	TAU Angle
Adina sayyad	21	f	332 002	85	82	3	4	88	30	99	127	56	31. 5
Manjun ath	23	m	341 462	89	87	2	2	90	34	92	130	60	33
Ashitosh ronge	19	m	358 669	87	89	-2	2	88	37	86	131	60	26
Rohit	19	m	337 465	79	89	-10	4	97	39	85	134	60	25
Arundhati jetri	25	f	241 12	77	76	1	1	79	27	88	116	52	29
Umesh	20	m	373 766	80	80	0	2.5	80	30	110	123	55	31

Vishvesh	25	m	391535	81	81	0	5	86	27	94	117	54	29
Divya salunkhe	18	f	661	79	75	4	4	82	27	125	117	54	30.5
gauri rathod	20	f	1234	91	87	4	2	89	29	95	124	56	31
gayatri rathod	19	f	1234	83	79	4	5	87	30	98	115	48	31.5
Prathamesh	15	m	124923	82	78	4	2	84	32	99	117	51	33.5
revansidh	19	m	34362	83	75	8	5	82	24	94	114	48	38
birudev	20	m	34363	87.5	81	6.5	2	85	31	89	119	53	32
piyusha	15	f	35437	80	78.5	1.5	0.5	85	32	99	120	54	33.5
sumitra	18	f	37109	85.5	81.5	4	3	89	34	94	123	56	35.5
atharv	20	m	36940	82	77	5	3.5	89	27	103	117.5	50.5	29
chandrika	20	f	35272	82.5	78	4.5	1	85	34	93	123	57	35
pratiksha	15	f	21892	82	79	3	1	87	28.5	94	119	53.5	30
sandhya rani	32	f	455549	78	73	5	6	86	33	93	122	54	34.5
Rani	26	f	24369	79	78	1	1	87	33	98	121.5	52	34
Akansha	20	f	24173	82	80	2	1	88.1	34	95.5	123.6	57.1	32.6
Mohini	17	f	41498	82	79	3	2	85	34	82	126	58.9	32.6
Nitin Kadam	21	m	31461	82	83	-1	3	88.5	37	86	124.5	57.7	26.5
Suhasini Gavali	21	f	36709	81	80	1	0.5	87.2	31	96	124.5	59.7	32.9
Pradnya Ghogade	15	f	39432	84	80	4.1	3	87	27	102	122.3	56.1	33.9
Vilas Dekhne	34	m	29983	85	78	7	4	84	23	98	115.8	54.6	38.6
Raju Balla	27	m	38726	78	80	-2	2.5	90	37	100	124.3	57.5	25.5
Sakubai Rathod	19	f	26962	81	80	1	1	86.5	28	100	121	52	29.8
Raviteja Rajul	23	m	39635	77.5	81	-3.5	0.5	88	35	55	123	54	33.5
Prajakta Patil	18	f	29864	80	75	5	3	84	23	113	119.7	58.7	34.8
Shreya nimbalkar	17	f	24442	82.6	78.9	3.7	1	86.8	31	100	124	57.7	33.3
Sushma Pawar	41	f	40286	90.6	88.7	1.9	1.5	89.5	35.5	92.6	134.5	62.4	29.2
trupti kembhavi	15	f	5601	84	78	6	4	88	24	96	118.6	53.2	37.6
harshada umate	18	f	34350	81	78	3	2	86	28	83	122.5	53.6	32.5
sakshi kunchate	18	f	35354	84	82	2	2	87.5	35	92	127.5	59.1	29.6
aishwari	22	f	392	83.8	75.	7.9	4.5	84	25	101	116.5	57.8	35.5

yavibhute			39		9								
Atharv dudhal	15	m	321 43	88.9	81.7	7.2	4	86.8	25	92	123.2	54.7	36
Poonam yadav	17	f	208 63	83.1	80.9	2.2	1	87.3	30	95	120.5	53	33.2
Omkar desai	20	m	369 40	82	78	5	3.5	89	27	103	120.5	53.9	31

Statistical Analysis

- **Pearson correlation** → relationship between TAU and other parameters
- **Intraclass Correlation Coefficient (ICC)** → agreement (ICC 2,1 model)
- **Bland–Altman analysis** → method agreement
- **Cohen's Kappa** → categorical agreement
- **ROC curve analysis** → diagnostic accuracy

Significance level set at **$p < 0.05$**

RESULTS

Correlation Analysis

TAU angle showed

- Strong positive correlation with ANB (r = 0.71)
- Moderate negative correlation with Beta (r = −0.55) and Yen (r = −0.45)
- Weak correlation with WITS and W angle
- Pearson correlation test

Parameter	r-value	p-value
TAU vs ANB	0.71	<0.001
TAU vs WITS	0.14	0.386
TAU vs Beta	-0.55	<0.001
TAU vs Yen	-0.45	0.004
TAU vs W	-0.28	0.083

Intraclass Correlation (ICC)

- Good agreement with ANB (0.69)
- Moderate agreement with Beta (0.58) and Yen (0.47)
- Poor agreement with WITS and W angle

Parameter	ICC	95% CI	Interpretation
ANB	0.69	0.50–0.82	Good
WITS	0.14	-0.18–0.42	Poor
Beta	0.58	0.33–0.75	Moderate
Yen	0.47	0.18–0.68	Moderate
W	0.26	-0.06–0.53	Poor

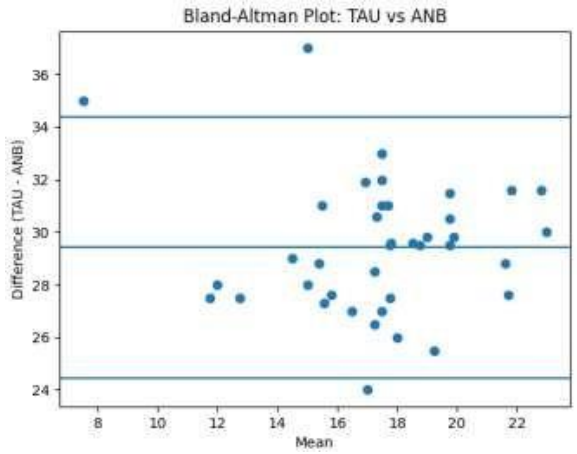
Kappa Agreement

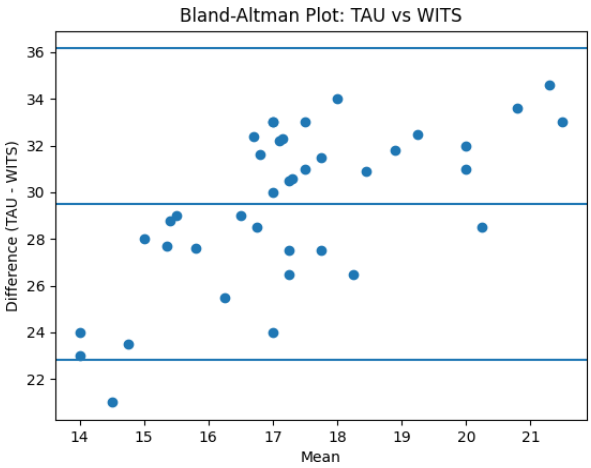
- Substantial agreement with ANB (κ = 0.61)
- Moderate agreement with Beta and Yen
- Fair to slight agreement with W and WITS

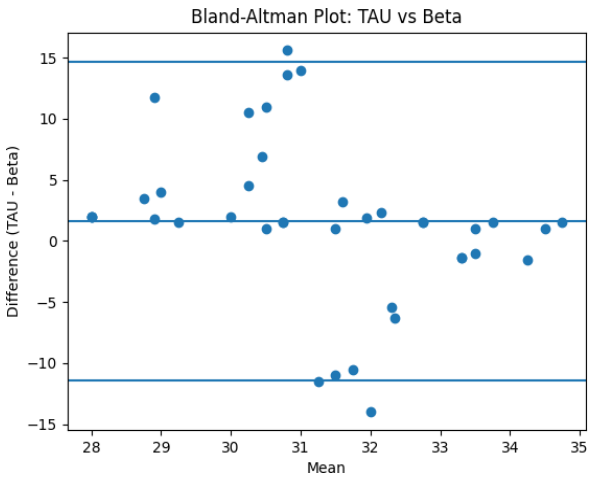
Parameter	Kappa	Agreement %	Interpretation
• ANB	• 0.61	• 75%	• Substantial
• Beta	• 0.52	• 70%	• Moderate
• Yen	• 0.46	• 66%	• Moderate
• W	• 0.31	• 60%	• Fair
• WITS	• 0.18	• 54%	• Slight

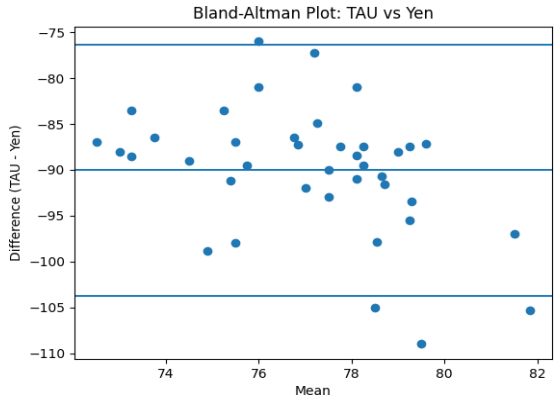
Bland–Altman Analysis

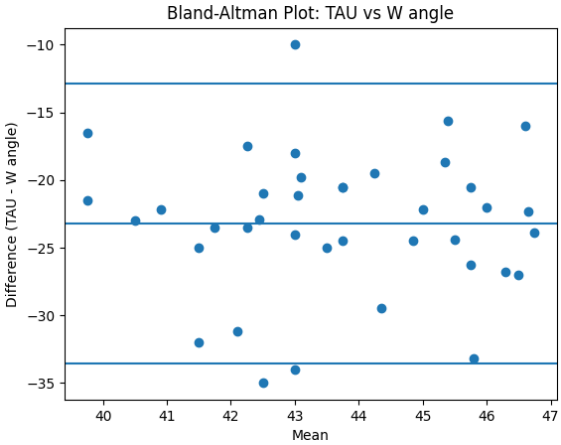
- Best agreement observed with Beta angle
- Systematic bias present with ANB and WITS
- Wide limits of agreement with Yen and W angle





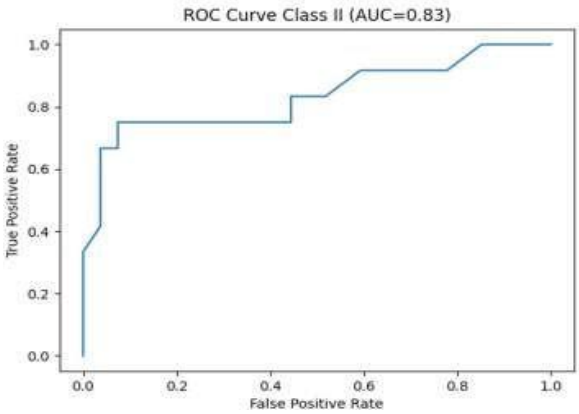




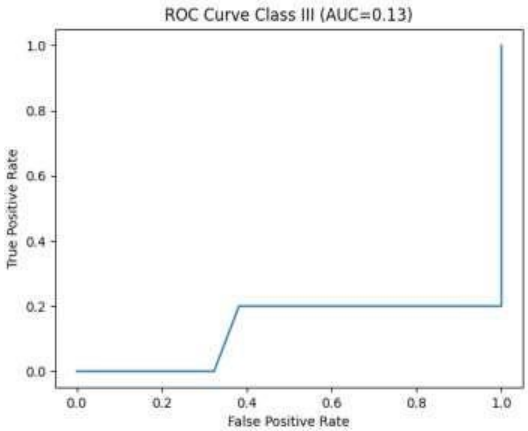


ROC Analysis

- Class II detection: AUC = 0.86



- Class III detection: AUC = 0.88



DISCUSSION

The present study evaluated the reliability and diagnostic validity of the TAU angle in comparison with established sagittal parameters. The results demonstrated that TAU angle exhibits strong correlation and substantial agreement with ANB angle, supporting its validity as a diagnostic tool.

The moderate negative correlation observed with Beta and Yen angles reflects their inverse diagnostic orientation. The superior agreement between TAU and Beta angle observed in Bland–Altman analysis suggests better clinical interchangeability.

The poor agreement with WITS appraisal may be attributed to its dependence on the occlusal plane, which is subject to variability. Similarly, W angle demonstrated limited agreement, possibly due to differences in geometric construction.

ROC analysis further confirmed the diagnostic accuracy of the TAU angle, demonstrating excellent ability to differentiate skeletal Class II and Class III malocclusions.

Method Error Analysis

To assess intra-examiner reliability, 10 randomly selected cephalograms were retraced after a 2-week interval. Method error was calculated using Dahlberg's formula, and no significant differences were observed ($p > 0.05$), confirming measurement reliability.

CONCLUSION

The TAU angle demonstrates good reliability and strong agreement with established sagittal parameters, particularly ANB. It shows promising diagnostic accuracy and may serve as a reliable adjunct in orthodontic assessment.

Clinical Implications

- TAU angle can be used as an alternative to ANB
- Less influenced by cranial base variations
- Useful in borderline cases

Limitations

- Limited sample size
- Two-dimensional analysis
- Single-center study

Future Scope

- 3D CBCT-based validation
- Larger population studies
- Longitudinal assessment

Ethical Statement

- This study was conducted in accordance with institutional ethical standards. As this was a retrospective cephalometric analysis, formal ethical approval and patient consent were not required.

Funding
- No external funding was received.

Conflict of Interest
The authors declare no conflict of interest.

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