

CORRELATION OF INTERCONDYLAR DISTANCE AND OCCLUSAL VERTICAL DIMENSIONS IN DENTATE INDIVIDUALS

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ABSTRACT

Objective: To determine the correlation between intercondylar distance and occlusal vertical dimension in dentate individuals.

Study Design: Cross-sectional study.

Place and Duration of Study: Department of Prosthodontics, Armed Forces Institute of Dentistry, Rawalpindi, from January 2025 to June 2025.

Methodology: One hundred dentate individuals aged 18–30 years with Class I occlusal relationship were selected through non-probability consecutive sampling. Intercondylar distance (ICD) was measured between bilateral Denar posterior reference points using digital vernier callipers with extended arms. Occlusal vertical dimension (OVD) was measured from subnasale to menton with a modified Willis gauge in maximum intercuspation. Pearson correlation and simple linear regression were applied.

Results: The mean age was 24.26 ± 4.13 years, and 56(56%) participants were female. The mean ICD was 140.72 ± 8.75 mm and the mean OVD was 65.15 ± 4.97 mm. ICD showed a moderate positive correlation with OVD ($r=0.525$, $p<0.001$) and explained 27.5% of its variance, giving the equation $OVD=23.184+0.298(ICD)$, with a standard error of estimate of 4.26 mm. Both measurements were greater in males ($p<0.001$). The correlation was significant in females ($r=0.410$, $p=0.002$) but not in males ($r=0.050$, $p=0.749$).

Conclusion: Intercondylar distance showed a moderate positive correlation with occlusal vertical dimension in dentate individuals; however, it accounted for only about one-quarter of the variation in occlusal vertical dimension, and the association differed between males and females.

KEYWORDS: Anthropometry, Dental occlusion, Jaw Relation Record, Mandibular Condyle, Vertical Dimension.

INTRODUCTION

Recording the correct occlusal vertical dimension (OVD) is one of the most critical steps in the rehabilitation of edentulous patients. OVD influences facial proportions, lip support, phonetics, masticatory efficiency and patient comfort. An excessive OVD may cause muscle fatigue, clicking of teeth and ridge soreness, whereas an inadequate OVD produces a collapsed facial appearance, angular cheilitis and reduced chewing efficiency.¹² After the loss of natural teeth, no fixed biological reference for OVD remains, and the clinician must rely on indirect methods. Techniques based on the physiologic rest position, phonetics, swallowing, facial aesthetics and pre-extraction records are all in routine use, but each involves a degree of subjective judgment, and their reported accuracy varies widely.³ A best-evidence consensus statement concluded that no single technique has been shown to be superior and that OVD is best established by combining several methods with sound clinical judgment.¹

This uncertainty has sustained interest in ^{stable} anthropometric proportions that could guide the clinician. Recent studies have derived regression formulas relating OVD to facial and hand measurements, including interpupillary distance, eye-to-mouth distance, palm width and finger length.⁴⁵ Such measurements are attractive because they are quick, non-invasive and require only simple instruments, although their reliability differs between sexes and ethnic groups.³

The intercondylar distance (ICD) is a further anthropometric reference of interest. It is determined by the width of the cranial base and, unlike the alveolar ridges and perioral soft tissues, is not expected to change after tooth loss. ICD has shown significant relationships with intercanine distance and maxillary central incisor width and has been proposed as a guide for the selection and arrangement of complete denture teeth.⁶ Clinically it can be approximated on the face by locating the arbitrary hinge axis on each side and measuring between these points, a procedure that can be completed chairside in edentulous as well as dentate patients.

Evidence on the relationship between ICD and OVD is limited and inconsistent. Bhat et al. reported a significant correlation ($r=0.619$) in a South Indian population and proposed a regression equation for estimating OVD.⁷ In contrast, a recent Pakistani study found only a weak, non-significant association between the two measurements.⁸ Because craniofacial dimensions vary between populations, equations derived elsewhere cannot be assumed to apply to local patients.

The objective of this study was to determine the correlation between ICD and OVD in dentate individuals and to derive a regression equation for estimating OVD from ICD. The null hypothesis was that no correlation exists between ICD and OVD.

MATERIALS AND METHODS:

This cross-sectional study was conducted in the Department of Prosthodontics, Armed Forces Institute of Dentistry, Rawalpindi, from January 2025 to Jun 2025, after approval from the Institutional Ethical Review Committee (ERC No. 918/Trg/Apr/2024). Written informed consent was obtained from every participant. The sample size was calculated with a correlation sample size calculator using a 5% level of significance, 90% power and an expected correlation coefficient of 0.619 between ICD and OVD.⁷ The minimum required sample was 23; a total of 100 participants were enrolled to improve precision and to permit analysis by sex. Non-probability consecutive sampling was used. For this study, ICD was defined as the distance between the rotational centres of the two condyles, approximated by bilateral skin reference points, and OVD as the vertical distance between two selected facial points (subnasale and menton) when the teeth were in maximum intercuspation.

Inclusion Criteria: Individuals aged 18–30 years of either sex, with a non-contributory medical history, Class I occlusal relationship and healthy periodontium were included.

Exclusion Criteria: Individuals with gross facial asymmetry, generalized attrition or abrasion, severe malocclusion associated with traumatic occlusion, temporomandibular joint disorders, or a history of jaw fracture or maxillofacial surgery were excluded.

Participants with one or two missing posterior teeth were not excluded, and the number of missing teeth was recorded. Each participant was seated upright in the dental chair, looking straight ahead with the head erect. The Denar posterior reference point, located 12 mm anterior to the superior border of the tragus and 5 mm below the tragus–outer canthus line, was used as the surface approximation of the condylar centre.⁷ A custom stainless-steel ruler with a 0.5-mm perforation at this position was aligned along the tragus–canthus line, and the point was marked on the skin bilaterally. The distance between the two marks was measured with digital vernier callipers fitted with extended arms, the tips of which lightly contacted the marked points, and was recorded in millimetres as the ICD.

Participants were then asked to bring the posterior teeth into maximum intercuspation and to relax the lips. A modified Willis gauge was placed lightly against the subnasale and the soft tissue menton, and the distance was recorded in millimetres as the OVD.⁹ Age, sex, number of missing teeth and occlusal relationship were entered on a structured proforma.

Data were analysed with IBM SPSS Statistics version 25.0. Age, ICD and OVD were presented as mean±standard deviation, and sex and missing teeth as frequencies and percentages. Normality was assessed with the Shapiro–Wilk test. ICD and OVD were compared between males and females with the independent-samples t-test. The relationship between ICD and OVD was assessed with the Pearson correlation coefficient for the total sample and for each gender. Simple linear regression was performed with OVD as the dependent variable and ICD as the predictor, and linearity, normality of residuals and homoscedasticity were checked with the normal Q–Q plot and a plot of standardized residuals against predicted values. To assess the robustness of the findings, the Spearman rank correlation was calculated because ICD and OVD departed slightly from normality, the Pearson correlation was repeated after excluding participants with missing teeth, and a partial correlation controlling for sex was computed. A p-value <0.05 was considered statistically significant.

RESULTS

Of the 100 participants, 56(56%) were female and 44(44%) were male, with a mean age of 24.26±4.13 years (range 18–30 years). All had a Class I occlusal relationship, and 19(19%) had one or two missing posterior teeth. Males had significantly greater ICD and OVD than females (Table-I).

Table-I: Descriptive statistics of study variables in the total sample and by sex (n=100)

Variable	Total (n=100)	Male (n=44)	Female (n=56)	p-value*
Age (years)	24.26±4.13	24.93±3.92	23.73±4.24	0.150
ICD (mm)	140.72±8.75	147.14±4.22	135.68±8.07	<0.001
Range	115–158	137–158	115–154	
OVD (mm)	65.15±4.97	68.23±4.74	62.73±3.67	<0.001
Range	56–75	56–75	56–74	

Values are mean±SD. ICD: intercondylar distance; OVD: occlusal vertical dimension. *Independent-samples t-test.

ICD showed a moderate positive correlation with OVD in the total sample; on analysis by sex, the correlation was retained in females but not in males (Table-II, Figure-1). The Spearman correlation gave a consistent result ($\rho=0.538$, $p<0.001$), as did the analysis after excluding participants with missing teeth ($r=0.579$, $p<0.001$, $n=81$). After controlling for sex, the partial correlation between ICD and OVD was 0.261 ($p=0.009$).

Table-II: Pearson correlation between intercondylar distance and occlusal vertical dimension

Group	n	r	95% CI for r	p-value
Total sample	100	0.525	0.366 to 0.654	<0.001
Males	44	0.050	-0.251 to 0.342	0.749
Females	56	0.410	0.165 to 0.607	0.002

Two-tailed test; CI calculated with Fisher's z transformation.

In simple linear regression, ICD was a significant predictor of OVD and explained 27.5% of its variance (Table-III). The standard error of the estimate was 4.26 mm. Residuals were normally distributed (Shapiro-Wilk $p=0.245$). The derived equation was: $OVD\text{ (mm)} = 23.184 + 0.298 \times ICD\text{ (mm)}$.

Table-III: Simple linear regression with occlusal vertical dimension as the dependent variable ($n=100$)

Predictor	B	SE	β	t	p-value	95% CI for B
Constant	23.184	6.890	—	3.365	0.001	9.511 to 36.856
ICD (mm)	0.298	0.049	0.525	6.103	<0.001	0.201 to 0.395

$R=0.525$; $R^2=0.275$; adjusted $R^2=0.268$; $F(1,98)=37.24$, $p<0.001$. B: unstandardized coefficient; SE: standard error; β : standardized coefficient.

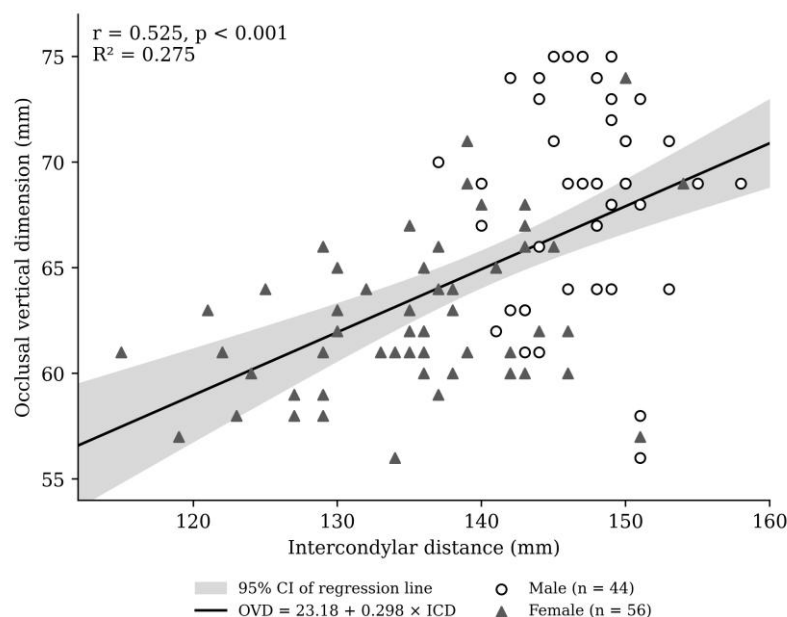


Figure-1: Scatterplot of intercondylar distance and occlusal vertical dimension with fitted regression line and 95% confidence band ($n=100$)

DISCUSSION

The present study found a moderate positive correlation between intercondylar distance and occlusal vertical dimension in young dentate adults, and the null hypothesis was therefore rejected. ICD explained just over one-quarter of the variability in OVD, indicating that the transverse and vertical facial dimensions are related but not closely enough for one to substitute for the other.

The correlation observed here ($r=0.525$) was lower than the $r=0.619$ reported by Bhat *et al.* in 258 South Indian adults, who used the same Denar reference point, extended-arm callipers and modified Willis gauge.⁷ Awotile *et al.* described a strong association between arbitrary surface ICD and OVD in a Nigerian sample measured with a facebow and Alma gauge.¹⁰ In contrast, Aziz *et al.*, using a comparable technique in 160 Pakistani adults, found only a weak and non-significant association ($\rho=0.18$).⁸ These inconsistencies are likely to arise from differences in ethnicity, sample composition, instrumentation and the reproducibility with which soft-tissue landmarks are identified.

Interest in ICD as a prosthodontic reference is longstanding and continues. It has shown significant relationships with interdental, intercanine and maxillary central incisor widths in South Indian populations, supporting its use as a guide to tooth selection and arrangement,^{6,11} and it has recently been evaluated specifically as a predictor of

vertical dimension in edentulous patients.¹² Its appeal lies in the assumption that cranial base width, unlike the alveolar ridges, is unaffected by tooth loss.

The absolute values recorded in this study differed from earlier reports. The mean ICD of 140.7 mm exceeded the 133.5 mm reported by Bhat *et al.*,⁷ and the mean OVD of 65.2 mm was nearly 10 mm greater. Part of this difference is methodological rather than anatomical. The skin-surface ICD includes the thickness of the soft tissue overlying the condyles, and the subnasale–menton distance is sensitive to the pressure applied by the gauge and to the identification of menton. Supporting this interpretation, a radiographic morphometric study of 366 panoramic images found no significant sex or age differences in intercondylar distance,¹³ whereas both this study and earlier surface-based studies found ICD to be significantly greater in males. Surface measurement therefore appears to capture soft tissue as well as skeletal variation, and standardized, calibrated protocols are essential before regression equations from different studies can be compared.

An important observation was that the association was not uniform across the sexes. It was moderate in females, absent in males, and weakened considerably once sex was controlled for, which suggests that much of the overall correlation reflects the generally larger craniofacial dimensions of males in both planes rather than a close proportional link within individuals. The narrower ICD range in males (137–158 mm) may also have limited detection of a correlation in that group. Bhat *et al.* reported significant correlations in both sexes,⁷ while Aziz *et al.* found a sex difference in ICD but not in OVD,⁸ and sex-dependent differences in the strength of anthropometric correlations have been described elsewhere.¹⁴ Pooled equations may therefore conceal meaningful subgroup differences.

Compared with other predictors of OVD, ICD performs modestly. Kaffaf and Şakar derived regression formulas from facial and hand measurements in 271 participants,⁴ Emam reported strong correlations between OVD and the outer-to-inner canthus distance in dentate individuals and the pupil-to-mouth-corner distance in edentulous individuals,¹⁵ and Basutkar *et al.* found finger lengths to correlate strongly with OVD while still advocating a pluralistic approach.⁵ Craniometric methods have also been compared with anthropometric ones,¹⁶ and a radiographic predictor, the intermental foramina distance measured on panoramic images, achieved a far stronger correlation with OVD ($r=0.95$) than any surface measurement.¹⁷ This pattern suggests that predictors based on hard-tissue landmarks outperform those measured over soft tissue.

From a clinical standpoint, the standard error of the estimate (4.26 mm) is the most relevant result, since it exceeds the freeway space of 2–4 mm usually regarded as acceptable. Freeway space is itself variable and influenced by muscle activity, occlusion and mandibular movement, and is difficult to predict from any single clinical variable,¹⁸ so an estimate of this precision could produce a clinically unacceptable change in OVD if used alone. This supports the consensus that OVD should be determined by combining several methods with clinical judgment,¹ and recent reviews similarly caution against relying on any individual anthropometric measurement given variation across sex and ethnicity.^{2,3} Digital face scanning, which shows close agreement with clinical calliper measurements, may improve the reproducibility of such measurements in future work.⁹

The main finding was robust to the analytical choices made. The rank-based correlation was similar to the Pearson coefficient despite mild departures from normality, and excluding participants with missing posterior teeth slightly strengthened rather than weakened the association, suggesting that one or two missing posterior teeth in an otherwise stable Class I occlusion did not meaningfully affect the recorded OVD.

This study had certain limitations. It was conducted at a single centre using non-probability sampling in young dentate adults with Class I occlusion, so the findings may not extend to older or edentulous individuals or to other occlusal relationships. Both measurements were made on soft-tissue landmarks and recorded to the nearest millimetre, and [intra-examiner reliability was not formally assessed / was assessed on a subset — please confirm]. The regression equation was also derived and evaluated in the same sample. Future multicentre studies should validate it in edentulous patients against pre-extraction records, derive sex-specific models, and assess whether digital or radiographic techniques improve prediction.

CONCLUSION

Intercondylar distance showed a moderate positive correlation with occlusal vertical dimension in dentate individuals, accounting for approximately one-quarter of the variation in occlusal vertical dimension. This relationship was evident among females but was not observed among males, indicating that the association between the two measurements is not uniform across both genders.

Conflict of Interest: None.

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