Original Article

A cephalometric analysis of Class II dentate subjects to establish a formula to determine the occlusal plane in Class II edentate subjects: A neo adjunct

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Abstract

Purpose: Occlusal plane (OP) differs considerably in participants with skeletal Class I and Class II participants. In this study, cephalometrics has been used to help in the determination of orientation of the OP utilizing the nonresorbable bony anatomic landmarks in skeletal Class II participants and an attempt has been made to predict and examine the OP in individuals with skeletal class II jaw relationship.

Materials and Methods: One hundred dentulous participants with skeletal Class II malocclusion who came to the hospital for correcting their jaw relationship participated in the study. Their right lateral cephalogram was taken using standardized procedures, and all the tracings were manually done by a single trained examiner. The cephalograms which were taken for the diagnostic purpose were utilized for the study, and the patient was not exposed to any unnecessary radiation. The numerical values obtained from the cephalograms were subjected to statistical analysis. Pearson's correlation of <0.001 was considered significant, and a linear regression analysis was performed to determine a formula which would help in the determination of orientation of the OP in Class II edentulous participants.

Results: Pearson's correlation coefficient and linear regression analysis were performed, and a high correlation was found between A2 and (A2 + B2)/(B2 + C2) with "*r*" value of 0.5. A medium correlation was found between D2 and (D2 + E2)/(E2 + F2) with "*r*" value of 0.42. The formula obtained for posterior reference frame through linear regression equation was $y = 0.018^* \times +0.459$ and the formula obtained for anterior reference frame was $y1 = 0.011^* \times 1 + 0.497$. It was hypothesized that by substituting these formulae in the cephalogram obtained from the Class II edentate individual, the OP can be obtained and verified.

Conclusion: It was concluded that cephalometrics can be useful in examining the orientation of OP in skeletal Class II participants.

Keywords: Cephalometrics, occlusal plane, pterygoid vertical, reference frames

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INTRODUCTION

Determination of occlusal plane (OP) is one of the critical clinical procedures in prosthodontic rehabilitation. OP forms the basis for ideal teeth position in establishing the occlusion, thereby achieving esthetics, phonetics, and mastication. Errors in determining the OP may affect the stability of a complete denture and ultimately result in alveolar bone resorption. This may have long-term implications in the dynamic stability of the temporomandibular joint.[1]

Soft tissue landmarks have been used since time immemorial for establishment of OP which included retromolar pad, buccinator groove, lateral surface of the tongue, parotid papilla, ala-tragus line, commissures of lip, and midway between the residual ridges.[2] Soft tissue landmarks are subjected to observer variability.[3] The OP differed considerably in skeletal class I, II, and III individuals.[4] Considering the importance of the accurate location of the established OP on function, esthetics, and speech, it seemed prudent to establish the original plane of occlusion as it existed in the natural dentition.[4,5]

Cephalometrics is the measurement of the cranial skeletal landmarks by means of lateral plane view radiographs of the head. It is a technique which utilizes reliable, nonresorbable hard tissue craniofacial structures. Hoafrath stated that cephalometrics is a useful tool for assessing the outcome of prosthodontic rehabilitation.[4,5] The present study was carried out to determine if the OP in skeletal class II edentate participants could be found out using nonresorbable bony anatomic landmarks and cephalometrics in dentate participants. This conceptualized fact was turned into an assemblance of genuinity considering the fact that the OP established in edentate participants should be similar to that which was present when they were dentate.[4,5]

MATERIALS AND METHODS

A total of 100 dentulous participants with skeletal Class II malocclusion were selected from Sri Sai College of Dental Surgery, Vikarabad, Telangana, India. A total of 100 participants would provide the data consistent to obtain a formula to determine the OP. The age of all the participants ranged from 18 to 35 years. Patients were included by the following selective criteria of having: (1) 28–32 teeth, (2) no systemic disturbances, (3) no abnormal mobility, and (4) post the cessation of growth of the individual. The patients who had (1) a history of orthodontic treatment and (2) presence of fixed or removable prosthesis

were excluded from the study. The selected individuals had reported to the Department of Orthodontics, and their selection was made based on the above-mentioned inclusion criteria before the start of any procedure undertaken to correct their jaw relationship. The participants were informed that they would not be subjected to any unnecessary radiation and no deviation in their treatment plan would be caused because of the study.

The entire study was cleared by the ethical committee of the institution. After taking the informed consent from the participants, the right lateral cephalogram of each of the participants was obtained through standardized procedures. Acetate sheets were taken and nonresorbable reference points were traced. The landmarks which were marked included porion-orbitale (Frankfort horizontal [FH] plane), gonion-gnathion (mandibular plane [MP]), anterior nasal spine-posterior nasal spine (palatal plane [PP]), OP (mesiopalatal cusp tip of maxillary first molar to the incisal edge of maxillary central incisor), pterygomaxillary fissure, and PTV (Rickett's pterygoid vertical (PTV)-tangent drawn from the posterior aspect of pterygomaxillary fissure taking the base as the FH plane as it was stable).[6] Only their diagnostic radiograph was used in the study which was duly returned to the orthodontist after the tracings were made and numerical values were recorded on acetate sheets.

A single trained examiner traced all the cephalograms to eliminate the disadvantage of operator variability. The intersection of FH and PTV has been found to be stable, i.e., any change in the location of this point as a result of patient's growth would be minimal.[7] The tracings made were the FH plane, PP, and OP which were stable cephalometric planes[8] and Steiner's MP. These would be considered as the horizontal reference planes as seen in Figure 1.
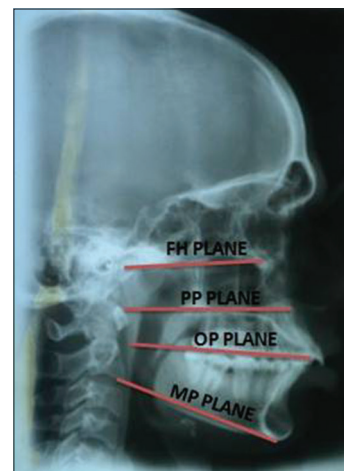

Figure 1: Cephalogram showing the horizontal frames of reference

The pterygomaxillary fissure was marked, and a tangent was drawn from the posterosuperior point behind and at right angles with the base as the FH Plane with the help of a protractor. This was termed as the Rickett's PTV. A line was drawn passing through the orbital parallel to the PTV with the help of set squares. These lines were considered as the vertical reference frames as seen in Figure 2.

The intersection between the horizontal and vertical frames of reference were marked on the PTV (posterior reference frame) on skeletal Class II participants as A2 (anterior reference frame) between FH and PP, B2 between PP and OP, and C2 between OP and MP. Similarly, on the parallel passing through orbital, the intersection points were marked as D2 between FH and PP, E2 between PP and OP, and F2 between OP and MP as seen in Figure 3.

The data obtained for all the skeletal Class II participants were tabulated in Table 1.

RESULTS

Pearson's correlation was found between the variables by taking their means and standard deviation. Since the MP is considered as an unstable reference frame, the FH plane was taken as a plane of reference in both the dentate and edentate population. The average and standard deviation calculated for the anterior reference frame have been tabulated in Table 2. The average and standard deviation calculated for posterior reference frame are tabulated in Table 3.

The values of high correlation ranged from 0.5 to 1.0, for medium correlation ranged from 0.3 to 0.5 or −0.3–−0.5, and for low correlation, it ranged from 0.1–0.3 or −0.1 to −0.3. The values suggested that there was a high correlation found between A2 and (A2 + B2)/(B2 + C2) with a Pearson's coefficient (*r* value) of 0.5. A medium correlation was found between D2 and (D2 + E2)/(E2 + F2) with an *r* value of 0.42. Pearson's correlation coefficient ranged from − 1 to 1 when plotted on a graph to find out the linear regression equation. A linear regression line has an equation of the form Y = c + mX, where X is the explanatory variable and Y is the dependent variable. The slope of the line is m and c is the intercept (the value of y when x = 0). A value of 1 implied that a linear equation described the relationship between X and Y perfectly, with all data points falling on a line, for which Y increased as X increased. A value of −1 implied that all data points fell on a line, for which Y decreased as X increased. A value of 0 implied that there was no linear correlation between the variables. With the above parameters, a regression equation was obtained to determine the OP cephalometrically, in the maxillomandibular spaces as given below. Refer Figure 4.

y = mx + c

y = 0.018*x + 0.459

Where, x = A2

Y = (A2 + B2)/(B2 + C2)

The points on the graph represent the participants in the study. Based on the line obtained, a positive or negative trend has been explained. When all the points lie on the same line, it indicates a perfect correlation with all the data points lying on a line on which Y increases as X increases. When the line slopes upward, it indicates a positive correlation, and when it slopes downward, it indicates a negative correlation. R^2 on the graph gives the value of regression coefficient.
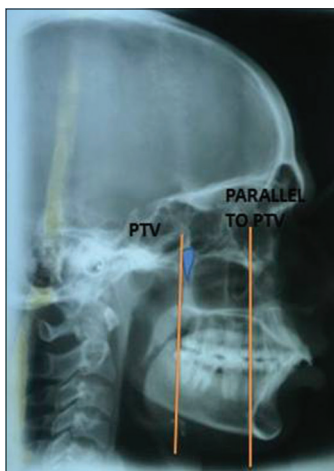

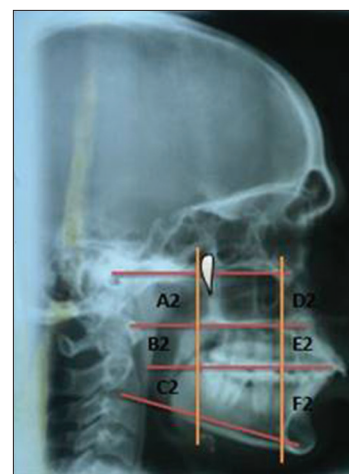**Figure 2:** Cephalogram showing the vertical frames of reference

Figure 3: Intersection of horizontal and vertical frames of reference in skeletal Class II participants

Table 1: Data obtained in skeletal class II subjects

A2	B2	C2	D2	E2	F2
23	19	28	25	24	37
24	16	40	28	26	51
20	23	28	22	30	38
25	18	29	22	28	48
19	19	28	21	21	34
23	22	25	21	27	38
26	22	41	24	35	55
22	21	27	23	28	40
22	18	34	23	26	45
27	14	33	26	23	36
24	18	25	28	23	34
27	13.5	30	27.5	21	38
22	16	25	22	23	32
24	15	29	24	25	38
21.5	28	36	24	22.5	37
24	21	26	25	25	42
23	20	32	24	27	42
18	16.5	23	20	21.5	34
25	14.5	22.5	20	21	34
20	17.5	24	21	24	36
24	16	26	28	23.5	32
25	19	20	27	26	30
23	18	31	27	26	41.5
28	19	29	25	26	39
20	15	27	23	21	34
28	20	24	25	27	38
26	16	29	28	22.5	40
24	18	36	25	24	46
23.5	21	34	26	29	47
22	17	27	20	24	38
28	11	24	28	24	38
25	21	25	27	26	38
24	16.5	23	25	23	34
19	16.5	28	20	21	34
23	18	34	25	24	45
27.5	18	25	27	23.5	35
23	22	38	26	27	52
25.5	16.5	31.5	27	23	35
23	18	26.5	25	20	28
22	24	29	25	25.5	42
21	20	33.5	22.5	23	43
21	21.5	33	25	26	43
24	17.5	31	23.5	26	42
18	23	35	20	29	52
22	13	27	24	18	33.5
23.5	19.5	37	26	25	50
26.5	20	38	30	24	45
21.5	23	29	26	28.5	37.5
23.5	15	23	24.5	20	30
23	19	27	25	23	31
26.5	22	35	25	31	45
26.5	21	22	26	24.5	29
26.5	18.5	23	27	22	31
26.5	21	31	17.5	28	38
26.5	21	31.5	29	27	38
26	23.5	31	28	26	38.5
30	20	33.5	29.5	26	40
26.5	25	25	26	26	35
28	23	39	28	26	50
25	17	23	28	20	39
25.5	21	33	27	24	43
20.5	22	38	20.5	24	35
28	15	33	28	24	36
21	17	29	22	22	38
21	22.5	29.5	24	26	38

Contd...

Table 1: Contd...

29	23.5	38	31	28	45
33	24	37	31	30	47
28.5	17	32	28	24.5	42
20	16	21	21	16	26
30	16	26	28	25	38
25	18	28	25	25	38
14	23	36	20	31	51
21.5	17.5	28	25	23	35
28	20	28	30	27	40
26	21	28	28.5	24	35
22	17.5	29	26	22	35
24	19	24	26.5	21	30
18.5	24	26	20	27	38
20	27.5	37	23.5	29	48.5
23.5	16	26	26.5	19	32
19	26.5	41.5	30	31	80
19	16.5	33	22	24	39
20	16	20	20	20	30
22.5	16	29	28	19	40
23	15	23	24.5	18	30
19	19	27	20	25	35
20	22.5	30	23	25	38
16	20	30	19	24	49
21	15	26	21	21.5	37
25	17	24	25	20	32
22.5	15	24	23	22	33
21	19	34	22.5	25	38
21.5	17	27	23.5	24	28
24	17.5	28	29	23	36
21	16.5	31.5	26	27	40
20	17	32.5	24	29	36
28.5	26	35	29	30.5	42
25	18	25	27	23	34
21.5	18	30	22	23	41.5
30.5	21.5	33.5	26	28	51.5

Vertical distance measures on the posterior (A2, B2, C2) and anterior reference planes (D2, E2, F2)- the values are in mm

Similarly, for the anterior reference frame passing through orbital, refer Figure 5.

$y1 = mx1 + c$

$y1 = 0.011* x1 + 0.497$

Where, x1 = D2

$y1 = (D2 + E2)/(E2 + F2)$

In Class II participants, A2 was correlated with A2 + B2/B2 + C2 and D2 was correlated with D2 + E2/E2 + F2 as the FH plane is taken as a stable reference frame. The important benefit of taking the values between A2 and (A2 + B2)/(B2 + C2) and D2 and (D2 + E2)/(E2 + F2) was that if one of them was absent, the best value of what is missing could be predicted from the measured value of the other. In terms of the formula y = mx + c, "y" represented the variable (A2 + B2)/(B2 + C2) and "x" represented A2. In the formula y1 = mx1 + c, "y1" represented (D2 + E2)/(E2 + F2) and "x1" represented D2. Since the values of A2, D2, B2 + C2,

Table 2: The average and standard deviation calculated for the anterior reference frame

	A	B	C	A + B	B + C	A + B/B + C
Average	23.54	20.6	29.505	44.14	50.105	0.888895
Standard Deviation	3.342926	15.93849	4.994186	16.11497	17.10755	0.107058
N	97	98	99	100	100	100

Table 3: The average and standard deviation calculated for the posterior reference frame

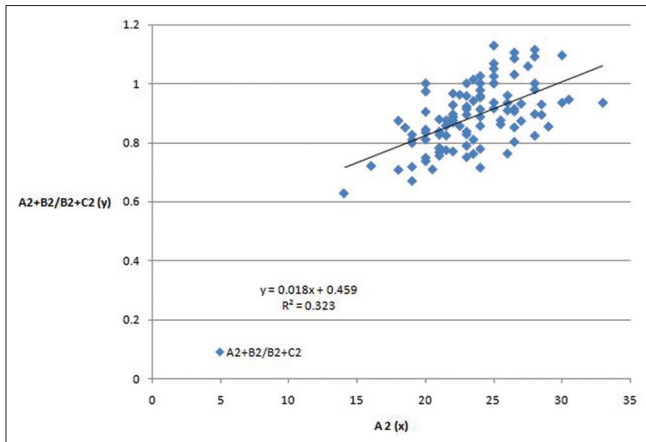|	A1	B1	C1	A1 + B1	B1 + C1	A1 + B1/B1 + C1
Average	24.86	24.595	39.065	49.455	63.66	0.786267791
Standard Deviation	3.022709	3.251025	7.399377	4.669423	9.818268	0.081864862
N	100	100	100	100	100	100

Figure 4: Graph showing linear regression equation between A2 and A2+B2/B2+C2
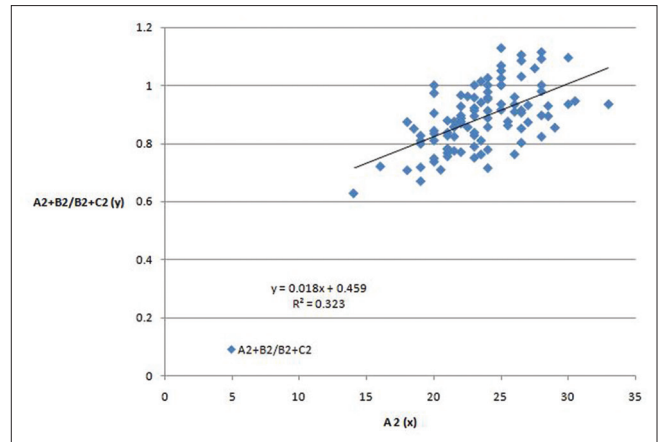

Figure 5: Graph showing linear regression equation between D2 and D2+E2/E2+F2

and E2 + F2 were established through cephalogram, the value of B2 and F2 could be predicted by substituting it in the formula. By obtaining a numerical value and substituting it on the anterior and posterior reference frames, the OP in the skeletal Class II jaw relationship in edentulous jaws could be predicted. The summary of the steps is explained in the flowchart as Figure 6.

DISCUSSION

Establishment of OP in edentulous participants has always remained a participant of inconclusive debates. OP has been established using soft tissue landmarks such as positioning it midway between the residual ridges, below the resting upper lip anteriorly and parallel to the Camper's plane posteriorly, at the same level as the lateral border of the tongue, at the level of buccinators groove,[9] commissure of the lips, posteriorly at the middle or upper third of the retromolar pad, and parallel to the parotid papilla.[2] Shigli *et al.* utilized these intraoral soft tissue landmarks and concluded that they are subjected to observer variability,[3] and they are also subjected to changes as the age advances.

Hard tissue landmarks, which are nonresorbable, relatively stable, bony, which were not subject to observer

variability have also been used to determine the OP through cephalometrics.[8,10] Many authors in their studies concluded that these hard tissue landmarks can be used as stable reference points.[4,8,10-21] O.P. Kharbanda had stated that pterygomaxillary fissure is a nonresorbable bony anatomic landmark which is stable throughout the aging of an individual.[6] Rickett's PTV is a line tangent to the posterior contour of the pterygomaxillary fissure and is used to represent the posterior border of the maxilla. As there is no change in the pterygomaxillary fissure and FH plane as the age advances, RTV can be taken as a stable reference frame. Any change, as a result of growth, would be minimal when compared from this reference frame. Since the parameters and the frames utilized in the current study were not in conformity with the other cephalometric studies previously conducted, no correlation with other studies could be made.

The landmark identification was greatly affected by the operator's experience as well as the tracing method. Intraobserver errors were found to be lesser than the interobserver errors. According to Kalra *et al.*,[22] the manual tracing yielded more reproducible results. Hence, a single trained examiner made all the tracings, and a manual method of tracing the cephalograms was used.
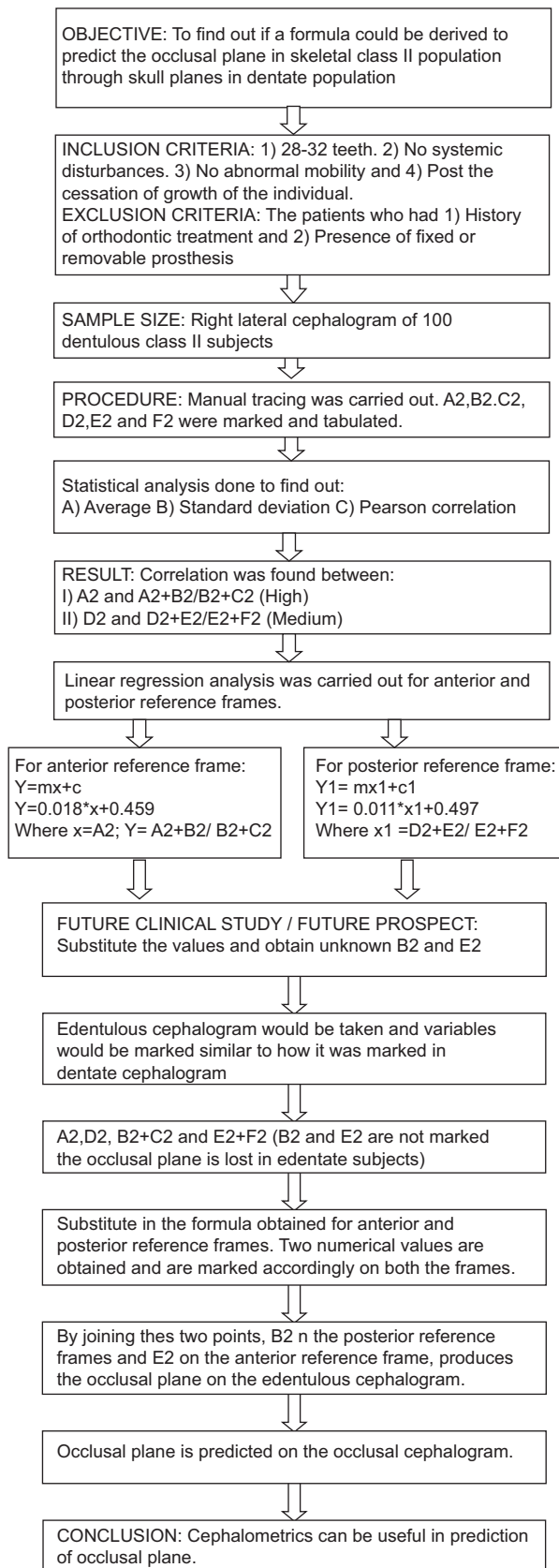
OBJECTIVE: To find out if a formula could be derived to predict the occlusal plane in skeletal class II population through skull planes in dentate population

INCLUSION CRITERIA: 1) 28-32 teeth. 2) No systemic disturbances. 3) No abnormal mobility and 4) Post the cessation of growth of the individual.
EXCLUSION CRITERIA: The patients who had 1) History of orthodontic treatment and 2) Presence of fixed or removable prosthesis

SAMPLE SIZE: Right lateral cephalogram of 100 dentulous class II subjects

PROCEDURE: Manual tracing was carried out. A2,B2.C2, D2,E2 and F2 were marked and tabulated.

Statistical analysis done to find out:
A) Average B) Standard deviation C) Pearson correlation

RESULT: Correlation was found between:
I) A2 and A2+B2/B2+C2 (High)
II) D2 and D2+E2/E2+F2 (Medium)

Linear regression analysis was carried out for anterior and posterior reference frames.

For anterior reference frame:
$Y=mx+c$
$Y=0.018*x+0.459$
Where $x=A2$; $Y=A2+B2/B2+C2$

For posterior reference frame:
$Y1=mx1+c1$
$Y1=0.011*x1+0.497$
Where $x1=D2+E2/E2+F2$

FUTURE CLINICAL STUDY / FUTURE PROSPECT: Substitute the values and obtain unknown B2 and E2

Edentulous cephalogram would be taken and variables would be marked similar to how it was marked in dentate cephalogram

A2,D2, B2+C2 and E2+F2 (B2 and E2 are not marked the occlusal plane is lost in edentate subjects)

Substitute in the formula obtained for anterior and posterior reference frames. Two numerical values are obtained and are marked accordingly on both the frames.

By joining thes two points, B2 n the posterior reference frames and E2 on the anterior reference frame, produces the occlusal plane on the edentulous cephalogram.

Occlusal plane is predicted on the occlusal cephalogram.

CONCLUSION: Cephalometrics can be useful in prediction of occlusal plane.

Figure 6: Flowchart to explain the steps of the study

The present study aimed to establish a positive correlationship between the numerical data of FH (i.e., A2 and D2) and the numerical data of the dentulous space obtained (i.e., B2 + C2 and E2 + F2) in the cephalogram of dentulous individuals. Since the reference frames used were nonresorbable, the equation obtained could be used to find out the variables B2 and E2 which would correspond to the OP in edentulous participants as well. The linear regression analysis was the mathematical equation arrived at which was correlatable in the edentulous group.

The practical value of the formula emerged when the problem of determining the OP was addressed in the edentulous population where it was lost. This was achieved by obtaining a lateral cephalogram of the patient, measuring the values of A2, D2, B2 + C2, and E2 + F2 and the OP for that individual was computed. In simpler terms, A2, D2, B2 + C2, and E2 + F2 could be obtained by tracing the horizontal and vertical reference frames in the edentulous group. These values could be substituted in the formula for obtaining two values for Class II individuals. A line drawn by connecting these two points at their specific numerical values would predict the lost OP in that individual.

As per the proposed hypothesis, it was presumed that after obtaining the lateral cephalogram of the edentulous individual and obtaining the values of B2 and E2 in skeletal Class II participants, it would be feasible to predict the OP in the particular edentulous group. Howsoever, it is felt that if the individual is a borderline skeletal Class I/II, an individual having excessive dentoalveolar compensation, complex changes in the stomatognathic system and in individuals receiving contemporary management or replacement of a traumatized dentition, there may be a limitation in utilizing the formula.

It is to be understood that we are still in the nascent stages and still much water has to flow under the bridge for us to come to terms with the virtual reality in the field of dentistry. Nevertheless, future projects may include checking the reliability of the cephalometric OP by substituting it in a clinical environment, constructing a device taking the orbital, and PTM as reference points to easily transfer the OP in the articulator. Different racial analysis can be done and if the same equation is found to exist for different races, then probably a software can be developed to integrate this formula with the virtual facebow transfers in Computer-aided design and computer-aided manufacturing technology. Through reflective optical active scanners and intraoral scanners,

we can integrate the computed tomography scan of the patient through transmissive absorption. Hence, this participant has a potential to revolutionize the concept of jaw relation recording in prosthodontics and may have wide implications in the rehabilitation of missing teeth.

CONCLUSION

From the present study, it was found that there exists a definite correlation between different anthropologic cephalometric planes and OP in Class II participants. An equation to determine the OP in edentulous participants has been proposed. The study was designed to look into the feasibilities of correctly establishing the OP using cephalometric landmarks. The future of this study could include that this formula could be used to aid in the development of OP clinically, to design a software to virtually correlate a facebow transfer to an articulator, and build a smile which the patient desires. However, further studies with bigger sample size can be of help to provide an insight into the anthropometric correlation between the various skull planes in different populations.

From the above-obtained results, it can also be concluded that the Rickett's PTV can be used as a stable cephalometric frame of reference for finding out the OP. Hence, it can be used as a reliable frame of reference which does not change as the participant ages. Positioning of the OP ultimately depends on the mature clinical judgment of the individual clinician and must satisfy esthetics, function, comfort, stability, and should not harm the long-term effectiveness of the temporomandibular joint.

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Conflicts of interest
There are no conflicts of interest.

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