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Comparative evaluation of accuracy and reliability of conventional method, thumb method and cephalometric measurements in determining vertical dimension at rest in completely edentulous patients- A randomized controlled clinical trial

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ABSTRACT

Background:

After complete loss of teeth the basic characteristics of occlusion are lost. Clinician faces the difficult challenge of establishing the parameters of occlusion, Many techniques have been used for measuring (vertical dimension) in dentulous and edentulous patients. The previous studies have considered ventral surface and soft tissue landmarks, which may not be consistent. Therefore, a bony landmark such as dorsal surface of thumb may be more reliable and definitive

Methods:

Patient reporting to the OPD of Prosthodontics department with treatment planning of complete denture were selected according to the inclusion and exclusion criteria and vertical dimension at rest was recorded using conventional, thumb and cephalometric measurements and were divided into three groups based on randomization. During try in freeway space, vertical

dimension at occlusion, centric relation, and esthetics were checked by two blinded Prosthodontist.

Results:

It was found that mean VDR values were highest in conventional group and lowest in Cephalometric group. The difference between the groups was found to be statistically significant (P = 0.001). Multiple comparison using post hoc test revealed statistically significant differences between conventional versus thumb method (P=0.018), Conventional versus cephalometric method(P=0.001) and between thumb versus cephalometric method(P=0.001)

Conclusion:

Conventional method (Nose-chin measurement) and thumb method were found to be more significant than cephalometric measurements, hence they can be used as effective aid in determining vertical dimension. Therefore it can be utilized as additional method for determination of vertical dimension at rest.

KEY WORDS:

cephalometric measurements, thumb measurment, vertical dimension at rest, vertical dimension at occlusion

INTRODUCTION

After the complete loss of teeth, the characteristics of occlusion are lost. Clinicians face the difficulty in establishing the parameters of occlusion such as the position and character of movement of lower jaw. Complete dentures function in the mouth as an integral part of the masticatory apparatus and are designed to conform to the patient's physiologic jaw relations.1 Jaw relationships of edentulous people should be determined and documented before manufacturing complete dentures.2 The use of the edentulous mandibular resting position as a baseline for the determination of the vertical dimension of occlusion presents several problems. The mandible is a movable structure and is unlikely that it will maintain a précise rest position for a great length of time. The vertical dimension is expressed in terms of vertical dimension at occlusion(VDO) and vertical dimension at rest (VDR).3

The determination of the physiologic rest position (PRP) of the mandible to the maxillae is of paramount importance in dentistry. The stability of vertical dimension at rest has been controversial, if the rest position of the mandible remains constant throughout life or not. Several studies have concluded that rest position remains constant throughout life irrespective of whether the patient is infant or adult. Several other studies demonstrated variability of rest position of the mandible before and after extraction of natural teeth and after complete denture insertion.4 Despite several studies on the rest position of the mandible and facial vertical dimension certain fundamental disagreements remain unresolved.

It has been suggested that an increase in VDO might cause clinical drawbacks, such as elevation of bite forces, muscle hypersensitivity, temperomandibular disorders, phonetic limitations and teeth tenderness.5 The decrease of VDO can compromise the aesthetic and causes morphologic changes in the complete denture wearers, leading to hyperactivity or hypoactivity of the masticatory muscles, increase or decrease in masticatory force, temporomandibular disorders, decreased facial height as a

result of mandibular ridge resorption and downward and forward rotation of the mandible and increasing mandibular prognathism.

Many techniques have been used for measuring vertical dimension in dentulous and edentulous patients ranging from pre-extraction records to use of swallowing, functionally acquired jaw position-associated phonetics and cephalometric radiographs.5 The standard aesthetic and phonetic approach is used to determine the VDO and the resting vertical dimension (VDR), but the limitation is the reference point such as soft tissue changes, thinning and elongation of the maxillary lip, drooping of nasal tip and columella of nose. Although advances in techniques and materials are being made in Prosthodontics, still no accurate method of assessing the vertical dimension of occlusion in edentulous patients is available. Clinical judgment plays a major role in the assessment of this important component in the construction of dentures which should satisfy the dentist and patient. So the best method is to consider criteria such as accuracy, reliability, adaptability of technique, complexity of equipment needed and length of time required securing the measurement.6

Even though a variety of techniques are being proposed and practiced for the evaluation of VDR, none of them is scientifically more accurate than others. Each method has its own limitations. They are either tedious, time-consuming, require special instruments/equipment or expose patients to radiation. Furthermore, a radiographic setup to provide lateral encephalography or an electromyography machine may not be available in most dental offices.7 Therefore, there is a need of a chair side procedure which can be reproducible.

Therefore, this study was conducted to assess the comparative evaluation of accuracy and reliability of conventional, thumb method and cephalometric measurements in determining vertical dimension at rest in completely edentulous patients.

MATERIALS AND METHODS

A Randomized controlled clinical trial was conducted in the Department of Prosthodontics and Crown & bridge, on edentulous patients with the chief complaint to replace their missing teeth. The informed consent (written) was obtained from the patient. All the steps of jaw relation (orientation, vertical, horizontal jaw relation) were done using conventional methods. The study was commenced after getting approval from the institutional review board IRB. NO (SVDC/IRB/2021/2701/PG/THESIS/08) and Institutional Ethical Committees & IEC NO (NO: 34/SVMCH/IEC-cert/feb21). The duration of study was Janwary-2021 to December 2022. All procedures performed in the study were conducted in accordance with the ethical standards given in 1964 declaration of Helsinki, as revised in 2013. Randomization of group done based on lottery allocation method.

Patients were selected based on following inclusion criteria; patient with treatment plan for a complete denture and healthy neuromuscular condition with class I ridge relation. Exclusion criteria was patient with TMJ disorder, neuromuscular disorder, psychiatric issues, hearing disorder, bone diseases and denture users.

SAMPLE SIZE CALCULATION:

The sample size of 60 (20 in each group adjusting for 10% drop out) was calculated based on the formula

$$\frac{(z_{1-\alpha/2}+z_{1-\beta})^2\ (\sigma_1^2+\sigma_2^2/r)}{(\mu_1-\mu_2)^2}$$

Alpha(α)-0.05

Beta(β)-0.2

Mean in group 1(μ1)-67

Standard deviation in group(σ1)-4.75

Mean group 2(μ2)-62.25

Standard deviation in group 2(σ2)-4.75

Ratio (group2/group1)-1

sample size needed for group1-20

sample size needed for group2-20

sample size needed for group3-20

total sample size needed-60

Drop out-10%(minimum total sample size -48, G_1=16,G_2=16,G_3=16

MATERIALS & METHODS

Sixty edentulous patients visiting the out patient Department of Prosthodontics, to replace their missing teeth reporting to the Department of Prosthodontics were included for the study. All the participants were divided into 3 groups using the lottery method with 20 patients in each group.
Vertical dimension at rest was determined by using the conventional Niswonger method in group I patients, thumb method in group II8 & cephalometric method in group III.9 Vertical dimension at rest measurement was obtained using a digital Vernier caliper and informed consent was obtained from the patient.

CONVENTIONAL METHOD

The patient should be seated in upright posture on dental chair, looking straight ahead, with jaw parallel to the floor and relaxed and was asked to “swallow, say ‘m’ repeatedly and relax. The patient was then trained to maintain the physiological rest position to minimize inaccuracies. The VDR was recorded from tip of nose to the prominent border of chin with digital Vernier caliper.(figure:1)

THUMB LENGTH

Patients were instructed to slightly bend the thumb finger and bony prominence was palpated. Measurement was obtained by drawing a line on the dorsal surface of bony prominent area of right thumb to the tip of thumb. The obtained value was used as VDR during jaw relation. (figure:2)

CEPHALOMETRIC METHOD:

The radiographic evaluation of VDR was conducted using standardized lateral cephalometric radiographs. Patient stood in natural posture with head placed in cephalostat and adjusted to Frankfort horizontal plane parallel to the floor. Ear rods and nasal support were used to stabilize the head during radiographic procedure. Lateral Cephalometric was taken on Sirona(orthophos XG) using ultra speed 8" x 10" X-ray film (Kodak), at a target distance of 5feet from the X-ray tube using 80 KVP, 15 milliampere and 1.5seconds exposure. Patients were instructed to say 'm', relax and lateral cephlometry was made. The radiographs were traced in an acetate paper to locate different anatomical landmarks. The cephalometric points -Anterior Nasal Spine (ANS) and Menton (Me) were marked. The obtained value used as VDR during jaw relation. (figure:3)

Other conventional steps in jaw relation were completed followed by articulation and teeth setting. Two blinded Prosthodontist evaluated VDR, VDO, freeway space, phonetics, centric relation and aesthetics using check list. If satisfied, denture fabrication was completed and if unsatisfied, the jaw relation procedure was repeated using conventional method and denture fabrication was completed. (figure:4)

STATISTICAL ANALYSIS

The data was analysed using SPSS for Windows [SPSS Ver 22.0, IBM Corp. Armonk, NY, USA]. The data was assessed for normal distribution using Shapiros test. Continuous data between the three groups was compared using One way ANOVA followed by post hoc Tukeys test. Inter-rater reliability was assessed using Kappa Statistics. Data was described using graphs and tables. The level of significance was set at $p < 0.05$.

RESULTS

This study compared three methods namely Conventional Method, Thumb Method and Cephalometric for Measurement of VDR. Graph.2 shows that the conventional group had the maximum VDR values followed by thumb method. In addition, Cephalometric method had the least VDR values. The difference between the mean values was found to be statistically significant. (Table 1) A post hoc test was conducted for multiple comparisons and it was found that mean difference in VDR values between Conventional method v/s Thumb method was less when compared to mean difference in VDR values between Thumb method v/s Cephalometric method and between Conventional method v/s Cephalometric methods.(Table:2)

An inter-examiner reliability analysis showed that Cephalometric method was not found to be

satisfactory method by both the evaluators. (Table: 3a, 3b, 3c.)

DISCUSSION

One of the most challenging clinical procedures in complete denture construction is the establishment of vertical dimension. In natural dentition, vertical dimension of occlusion always remains constant irrespective of non-carious destruction due to attrition. But once VD is lost, it's very difficult to re-establish. Facial aesthetics gives a clue to the correct vertical dimension. Strained appearance indicates excessive vertical dimension, whereas compressed lips with folds around the mouth indicates reduced vertical dimension. Literature review states various techniques and methods to determine vertical dimension and record VDR and VDO such as special gauges, tattoo marks, cardboard profiles, measurement of closest speaking space and cephalometry. Subjective method (patient perceived comfort, rest position of mandible, aesthetic and phonetics) require a certain level of clinical experience and are difficult to master. Objective methods (cephalometric radiographs, anthropometric measurements from face and body parts, maximum biting force, electromyographic method and pre extraction records) are easy to measure, relatively constant throughout life and are easily accessible. But there is no single proven gold standard method for recording the same, which on repeating never gives same value.10

However anthropometric measurements such as facial measurements and finger length serve as basic guide and their objective nature eliminates the guess work which is common in subjective method. Anthropometric readings have found to be within the range of 2-4mm when compared to a range of 0-14mm from other methods.10 These anthropometric methods are also economic, non invasive, simple, reliable,does not required sophisticated measuring devices and provide reproducible values for future reference.

Many established techniques used are subjected to individual assessor variability. One of the most popular conventional technique advocated by Swerdlow was the point and gauge method of Pleasure, which measures the distance between nose and chin on the mid line of the patient by a ruler.10The procedure was repeated multiple times, till a stable rest position were obtained. The vertical dimension of occlusion was determined by reducing 2-4 mm from the rest position. Satish Babu et al in their study, found out the difference varying between VDO and VDR was 1.8 to 2.3 mm, but the mean value was not statistically significant. Dale Smith in his study analyzed the pre extraction records which were found to be more reliable. He found a mean difference of 1.3 mm when the measurements were compared with Cephalometric measurements.11

But the accuracy of pre extraction record over a long period of edentulousness may be questionable. The clinical establishment of vertical dimension is based on the premise that the vertical dimension of occlusion of the patient with natural teeth is likely to be the best one for the new edentulous state and therefore should be reproduced. This premise has not been studied scientifically and remains an unproved assumption. 12 In our study the Vertical dimension at rest correlated significantly with the conventional method (phonetic used of letter "M", $p = 0.001$). This is well supported and documented in various literatures. Fouad MM et al13 in their study found that Arabic letter (edd) can be used as a

tool for evaluation of vertical dimension, Dipoyono HM et al14 concluded that phonetic, photographic, and photo-analytical methods can be used to determine vertical dimension. However, the result of current study found that conventional method used to establish vertical dimension at rest in 20 patients was in contrary to the findings by Bhat VS et al15 who found that there was decrease of 2.5mm in vertical dimension than pre-extraction cephalometric value and concluded that the conventional method of recording vertical dimension using clinical assessment method is not reliable to obtain vertical dimension measurement that existed before extraction.

In our study the vertical dimension at rest did not correlate significantly with the Cephalometric method, which is in consensus with the study done by Uppal et al 16 who stated that Cephalometric method is not a reliable method to determine vertical dimension at rest. Similarly Enkling N et al17 also found that Cephalometric method is not a reliable method to determine vertical dimension at occlusion. However, the literature has contrary reports also which states that Cephalometric measurements correlated with vertical dimensions, such as study done by Zielak JC et al18 who found that Cephalometric method can also be used to determine vertical dimension at occlusion. In our study, the vertical dimension at rest correlated significantly with the length of thumb. This is similar to study done by Haroon TM et al19 who documented that length of thumb correlates with the vertical dimension at rest in 200 patients. This finding also corresponds with Basutkar N et al20 who found that the length of index finger(from tip to base of index finger)followed by thumb finger(measured from tip to base of thumb finge) correlates with vertical dimension at occlusion. Sajjan et al 8 also in their study correlated VDR of dentate patients with the thumb length and concluded that correlation between thumb length and VDR is significant, which is also in accordance with our study. The previous study considered ventral surface and soft tissue landmarks which are not consistent and reliable. Although some studies have shown racial and gender differences in various hand anthropometric measurements, however none of the studies have reported correlation of anthropometric measurements using thumb length(bony landmarks) with VDR.8In our study length of thumb(dorsal surface, bony landmark) was similar to VDR which is not in consensus with Singh DK et al 21 who found that distance between tip of index finger to tip of thumb finger value had closest correspond with vertical dimension at occlusion.

In our study thumb finger of right hand length was significantly matched with VDR in 20 edentulous patients. Similar results for correlation of VDO with length of thumb have been conducted by Tripathi S et al 22. In his study, thumb length in men and women and the distance between tip of index finger and tip of thumb finger correlated with vertical dimension at occlusion in 500 dentate subjects, Ladda et al 23 also found that distance from tip of index finger to tip of thumb finger of right hand with 400 subjects correlated with vertical dimension at occlusion.

Babu BB et al3 found that thumb length correlated with vertical dimension at occlusion. v Bajunaid SO et al24 found that anthropometric measurements like distance from the tip of index finger to the tip of thumb finger did not correlate with the vertical dimension at occlusion. This finding is in

contrary with the current study, where the vertical dimension at rest correlates with the anthropometric measurements (length of thumb finger in 20 patients).However, the result of current study found that thumb method was used to establish vertical dimension at rest in 20 patients, was in contrary to the findings by KhanehzadM et al25 on 200 Iranian subjects who found that thumb length was not correlated with vertical dimension at occlusion. Similar findings were reported by Helal MA et al who found that anthropometric measurement does not correlate with occlusal vertical dimension,26 Moreover in another study by Janhavi JR 27et al stated that anthropometric measurement of little finger length did not correlate with vertical dimension at occlusion, Nazir S et al28 conducted a study in Kashmiri populations and found that length of thumb finger did not correlate with the vertical dimension at occlusion and Munshi M et al29 in his study found that distance between the tip of index finger to tip of the thumb finger did not correspond with the vertical dimension at occlusion.

Therefore, the results of our study and many other similar studies cited in the literature indicates that anthropometric measurements such as thumb finger length can serve as a basic guide in determining the VDR and offer significant prosthetic advantages. The objective nature of these methods eliminates the guess work involved in subjective methods to determine VDR such as resting jaw position or swallowing. The measurement of thumb length to determine VDR is user friendly chairside procedure since it is easy, economic, intra-operative and reliable. It does not require radiographs or sophisticated measuring devices and provide reproducible values for future reference. These methods do not require a great amount of time and experience to master. Considering the limitations of the current study such as smaller sample size, in each group inclusion of only subjects with Class I occlusion and difficulty in the taking facial readings for subjects with excessive soft tissue bulk under the chin, it is further recommended to do similar analysis in larger sample size and different ethnic groups 3 to substantiate the results.

CONCLUSION

Within the limitations of current study it is concluded that conventional method (Nose-chin measurement) and thumb method are more reliable and dependable than Cephalometric method and hence are found to be a very effective aid in determining vertical dimension at rest. These methods are user friendly. Moreover it is simple chair side procedure . This method eliminates bias due to multiple measurements .Therefore Nose - Chin method and Thumb method can be utilized as additional method for determination of vertical dimension at rest [VDR].

LIST OF FIGURES:

Figure: 1 VDR recorded using conventional method

Figure: 2 measurement of VDR using thumb method

Figure: 3 measurement of VDR using Cephalometric

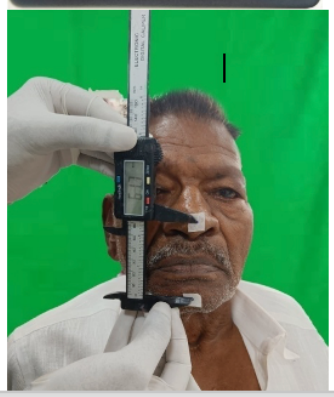
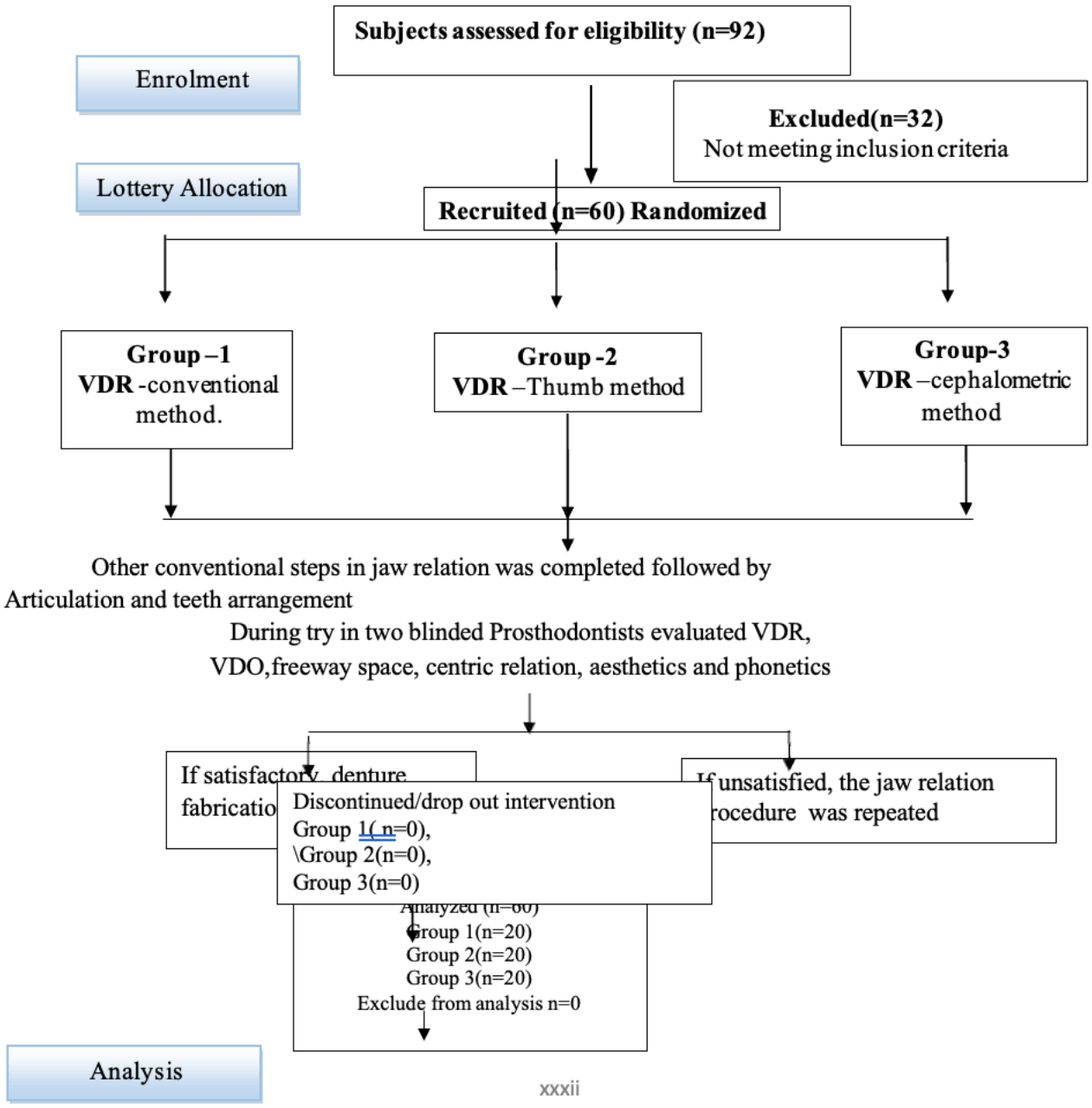


Figure: 4 VDR using conventional method

LIST OF GRAPH:

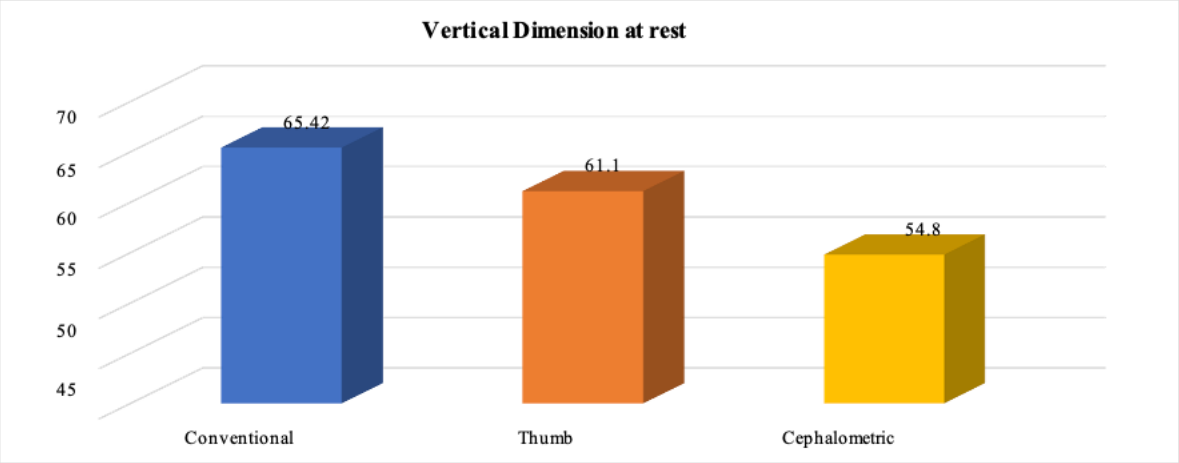
Graph:1

CONSORT FLOW CHART



xxxii

Graph 2: Mean VDR values obtained using three different methods



LIST OF TABLES:

Table 1: Comparison of mean VDR values between three different methods

Groups	N	Mean ± SD	F	p Value
Conventional	20	65.4 ±6.5	24.44	p = 0.001**
Thumb	20	61.15 ± 3.6		
Cephalometric	20	54.85 ± 3.6		

level of significance at p < 0.05; N-Number; SD-Standard Deviation

***Statistically significant using One Way ANOVA*

Table 2: Multiple comparison between the groups using post hoc test

Group		MD	p Value	95 % Confidence Interval	
				Lower Bound	Upper Bound
Conventional	Thumb	4.275	p = 0.018*	0.615	7.93
	Cephalometric	10.57	p = 0.001**	6.91	14.23
Thumb	Conventional	-4.275	p = 0.018*	-7.93	-0.615
	Cephalometric	6.295	p = 0.001**	2.63	9.95
Cephalometric	Conventional	-10.57	p = 0.001**	-14.23	-6.91
	Thumb	-6.295	p = 0.001**	-9.95	-2.63

Level of significance at p < 0.05; MD-Mean difference

Statistically significant at *p < 0.05 and **P < 0.01 using Tukey's post hoc test

Table 3a: Inter evaluators level of agreement for conventional method

		Evaluator 2			Kappa Value	p value
Conventional		**Satisfied**	**Unsatisfied**	**Total**		
Evaluator 1	Satisfied	19	0	19	1	p = 0.001**
	Unsatisfied	0	1	1		
	Total	19	1	20		

Table 3b: Inter evaluators level of agreement for thumb method

		Evaluator 2			Kappa Value	p value
Thumb		**Satisfied**	**Unsatisfied**	**Total**		
Evaluator 1	Satisfied	19	0	19	1	p = 0.001**
	Unsatisfied	0	1	1		
	Total	19	1	20		

Table 3c: Inter evaluators level of agreement for Cephalometric method

		Evaluator 2			Kappa Value	p value
Thumb		**Satisfied**	**Unsatisfied**	**Total**		
Evaluator 1	Satisfied	0	0	0	-	-
	Unsatisfied	0	20	20		
	Total	0	20	20		

LEGENDS:

Figure: 1 VDR recorded using conventional method

Figure: 2 measurement of VDR using thumb method

Figure: 3 measurement of VDR using Cephalometric

Figure: 4 VDR using conventional method

Graph:1 Consort flow chart

Graph: 2 Mean VDR values obtained using three different methods

Table:1 Comparison of mean VDR values between three different methods
Table 2: Multiple comparison between the groups using post hoc test
Table 3a: Inter evaluators level of agreement for conventional method
Table 3b: Inter evaluators level of agreement for thumb method
Table 3c: Inter evaluators level of agreement for Cephalometric method

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