Prediction of changes in the arch dimensions after orthodontic treatment by a mathematical equation

Utkarsh Gandhi[1], Kunal Shah[2], ShivpriyaAher[3], Nitin Gulve[4], Amit Nehete[5]

[1](Department of orthodontics and dentofacial orthopaedics, M.G. V's K.B.H. Dental College and Hospital Nashik/ MUHS. India)

[2](Department of orthodontics and dentofacial orthopaedics, M.G. V's K.B.H. Dental College andHospital Nashik/ MUHS. India)

[3](Department of orthodontics and dentofacial orthopaedics, M.G. V's K.B.H. Dental College and Hospital Nashik/ MUHS. India)

[4](Department of orthodontics and dentofacial orthopaedics, M.G. V's K.B.H. Dental College and Hospital Nashik/ MUHS. India)

[5](Department of orthodontics and dentofacial orthopaedics, M.G. V's K.B.H. Dental College and Hospital Nashik/ MUHS. India)

Corresponding Author: Utkarsh Gandhi

Abstract: *Arch perimeter (AP), inter-canine width (ICW) and inter-molar width(IMW) are essential for diagnosis and treatment planning and are closely related factors in orthodontics. The aim of the present study was to determinethe relationship between arch perimeter (AP), inter-canine width (ICW) and inter-molar width (IMW); and prediction of post-treatment arch perimeter based on pretreatment arch perimeter measurements. The sample included 20 sets of good quality plaster models of 10 males and 10 females with the mean age of 18years (11-26years); each of Angle's Class I bimaxillary protrusion and Class II division 1 malocclusion patients who were treated in MGV'S KBH Dental College and Hospital, Nashik. Pre-treatment &Post treatment models for maxillary and mandibular arches weremade. There was a correlation between arch perimeter and ICW (AP = 1.39 ICW + 23.9) for class I bimaxillary protrusion, (AP = 0.4 ICW + 60.03) for class II division 1,similar regression equations were established for arch perimeter and IMW both pre-treatment and post-treatment and also between pre-treatment arch perimeter and post-treatment arch perimeter.Correlation makes it possible to predict the size of one variable by knowing the size of other. Changing the arch width is one of the reasons for relapse. Obtaining the regression equation can be helpful for predicting the change in arch perimeter after orthodontic treatment and thus would be helpful in orthodontic treatment planning.*

I. Introduction

The current trends in the practice of orthodontics have shifted toward the principles of dentofacial orthopaedics and non-extraction treatment modalities. Transverse expansion of maxilla because of its potential for increasing arch perimeter to alleviate crowding in the maxillary arch without adversely affecting facial profile is becoming the subject of renewed interest.[1]

It has been established by studies that change in the transverse dimension would alter the arch perimeter AP. But for orthodontic treatment planning it is important for the clinicians to exactly determine the post treatment AP in different clinical cases.[2]

Ricketts et al. (1982) in their study found that for each millimeter of arch width increase at the canines and molars, AP increased by 1 mm and 0.25 mm, respectively. But the method to obtain these values was not included in the study.[3]

Adkins et al. (1990) showed that there was an increase in the maxillary arch perimeter of approximately 0.7 mm with the use of Hyrax appliance for rapid palatal expansion.[4]

Motoyoshi et al. (2002), in a studyestimated the increase in arch perimeter associated withmandibular lateral expansion where he showed that a there is 0.37mm increase of arch perimeter for 1 mm increase in intermolar width (IMW).[5]

Prediction of the change in arch perimeter (AP) as a consequence of transverse expansion and in different clinical cases could be helpful in orthodontic treatment planning.[6]

The aim of the present study is to determine the relationship between arch perimeter(AP), intercanine width(ICW) intermolar width(IMW); and prediction of post-treatment arch perimeter based on the pre-treatment arch perimeter measurements.

II. Material and Methods

The sample consisted of 20 sets of good quality plaster models each of Angle's Class I bimaxillary protrusion and Class II division 1 malocclusion patients who were treated in MGV'S KBH Dental College and Hospital, Nashik. Both pre-treatment & post treatment models for maxillary and mandibular arches were made. The sample included 10 males and 10 females with the mean age of 18years (11-26years)

Study Design: Retrospective study
Study Location: Department of Orthodontics and Dentofacial Orthopaedics MGV's KBH Dental College and Hospital, Nashik, Maharashtra

Study Duration: November 2017 - December 2017.
Sample size: 20
Subjects & selection method: 20 sets of casts each for Angle's class I malocclusion (Pre-treatment and post-treatment) and Angle's class II Division 1 malocclusion (Pre-treatment and post-treatment)were randomly selected from the records of department of orthodontics at MGV's KBH Dental college and Hospital, Nashik, Maharashtra.

Inclusion criteria:
1. Fully erupted permanent dentition from first molar to first molar.
2. Good-quality casts
Exclusion criteria:
1. Tooth agenesis,
2. Large restorations or teeth with different shapes that could change the mesiodistal diameter of the tooth

Procedure methodology
The following linear measurements were performed were accurately measured in millimeter using digital Verniercaliper.
1. Upper and lower inter-canine widths (ICW) - maximum linear width between the canines. (fig. 1)
2. Upper and lower intermolar widths (IMW) - maximum linear width between molars at their buccal surface. (fig.2)
3. Upper and lower arch perimeter (AP)— ideal line between every mesial and distalcontact point of each permanent tooth from the mesial of the first molar to the mesial of the first molar of the opposite side. AP was measured using brass wire and Digital Vernier Caliper (fig. 3)

Figure: 1 Inter-canine width (ICW)**Figure: 2** Inter-molar width (IMW)**Figure: 3**Arch perimeter (AP)

Statistical analysis
To find the average relationship between AP and ICW and AP and IMW separately for Angle's Class I Bimaxillary Protrusion and Angle's Class II Division 1 malocclusion sample units in each of maxillary and mandibular measurements of AP, ICW, IMW; the regression lines are fitted to the measurements of each of 20 sample units separate as per the results in table 1& 2.
Similarly, the average relationship between pre- and post- treatment values of AP was also obtained for Class I and Class II sample units with maxillary and mandibular measurements. The results obtained of the fitted regression line are shown in table 3

III. Result

All the equations are best fit for estimating AP for known values of ICW or IMW respectively table 1. In all above equations the intercept shows the average value of AP if ICW or IMW is taken zero respectively for the said equation. The slope represents the rate of change in AP as ICW or IMW changes respectively (for table 1 and 2)

The intercepts in the equations shows the average value of post-treatment AP when pre-treatment AP is taken as zero in respective equations, while slope represents the rate of change in value of post-treatment AP as pre-treatment AP changes respectively for the particular equation. (for table 3)

Table no 1: Regression equation showing relation between pre-treatment and post-treatment inter-canine width (ICW), inter-molar width (IMW), and arch perimeter (AP) for Angle's Class I with bimaxillary protrusion

Class	Arch	Treatment time	Regression equation	Intercept	Slope
Angle's Class I with bimaxillary protrusion	Maxillary	Pre-treatment	AP =1.39 x ICW + 23.91	23.91	1.39
			AP = 1.19 x IMW + 7.77	7.77	1.19
		Post- treatment	AP = 2.18 x ICW -19.88	-19.88	2.18
			AP = 1.14 x IMW - 0.44	-0.44	1.14
	Mandibular	Pre-treatment	AP = 0.44 x ICW + 48.82	48.82	0.44
			AP = 1.20 x IMW – 1.31	-1.31	1.20
		Post -treatment	AP = 1.98 x ICW - 6.76	-6.76	1.98
			AP = 1.14 x IMW - 5.94	-5.94	1.14

Table no 2: Regression equation showing relation between pre-treatment and post-treatment inter-canine width (ICW), inter-molar width (IMW), and arch perimeter (AP) for Angle's Class II Division 1

Class	Arch	Treatment time	Regression equation	Intercept	Slope
Angle's Class II division 1	Maxillary	Pre-treatment	AP = 0.45 x ICW + 60.03	60.03	0.45
			AP = 0.12 x IMW + 69.45	69.45	0.12
		Post- treatment	AP = 0.18 x ICW + 55.92	55.92	0.18
			AP = 1.35 x IMW – 9.84	-9.84	1.35
	Mandibular	Pre-treatment	AP = 0.20 x ICW + 57.41	57.41	0.20
			AP = 0.37 x IMW + 43.76	43.76	0.37
		Post-treatment	AP = 0.23 x ICW + 47.40	47.40	0.23
			AP = 0.55 x IMW + 26.10	26.10	0.55

Table no 3: Regression equation showing relation between pre-treatment arch-perimeter and post-treatment arch perimeter

Class	Arch	Regression equation	Intercept	Slope
Angle's Class I with bimaxillary protrusion	Maxillary	Post-treatment AP = 0.58 x Pre-treatment AP +16.25	16.25	0.58
	Mandibular	Post-treatment AP = 0.56 x Pre-treatment AP +15.55	15.55	0.56
Angle's Class II Division 1	Maxillary	Post-treatment AP = 0.45 x Pre-treatment AP + 27.75	27.75	0.45
	Mandibular	Post-treatment AP = 0.18 x Pre-treatment AP + 42.36	42.36	0.18

IV. Discussion

The study of the relationship between several arch measurements is important in orthodontics. Predicting the changes that would occur in the course of treatment could help the clinician in getting a better idea to plan the orthodontic treatment.

ICW IMW and AP were measured using Digital Vernier Caliper for 20 pre-treatment casts and 20 post-treatment casts (both arches) separately for Angle's Class I malocclusion and Angle's Class II Division 1 cases. Using these values regression equations were established.Linear regression analysis was applied and theslope and intercept were determined.

Paulino V. etal in their study showed that for an increase of 1 mm in ICW, the AL increases approximately 1.36 mm with a 95 per cent CI. [2]

Germane et al. (1991) found a correlation between AL and ICW using a mathematical model of the dental arch. They reported that arch perimeter increases due to inter-canine expansion were intermediate between those of the incisors and molars, the first millimetre of expansion causing a 0.73 mm increase in the perimeter.[7]

Hnat et al. (2000) stated that, from a clinical point of view, most of the ALincrease occurred in the anterior segment for all alterationsin arch width.[8]

Currently no study has been done which could predict post treatment AP based on the pre-treatment values. In present study, it must be emphasized that a regression equation could be established between AP and ICW, AP and IMW, for Angle's class I Bimaxillary Protrusion as well as Angle's Class II division 1 malocclusion cases.So, knowing the values of ICW or IMW can help us predict AP and vice versa. Also, an average relation between post treatment AP and pre-treatment AP was obtained. Thus, post treatment AP could be calculated from pre-treatment AP

The further scope of this study is that all the parameters were measured using digital Vernier calliper. Instead Digital dental cast could be used which is easy and accurate method for measurements along with other advantages such as storage and immediate data transmission. Other limitations include small sample size, also the groups could be further divided upon the tooth extractions for different types of malocclusions.

V. Conclusion

Correlation makes it possible to predict the size of one variable by knowing the size of other. Changing the arch width is one of the reasons for relapse. Obtaining the regression equation can be helpful for predicting the change in arch perimeter after orthodontic treatment and thus would be helpful in orthodontic treatment planning.

References
[1]. Haas AJ. Just the beginning of dentofacial orthodpaedics. Am J Orthod Dentofacial Orthop1970; 57: 219-55.
[2]. Paulino V, Paredes V, GandiaJL and Cibrian R. Prediction of arch length based on intercanine width. Eur J Orthod2008;30:295–298.
[3]. Ricketts RM , Roth RH , Chaconas SJ , Schulhof RJ , Engel GA. Orthodontic diagnosis and planning. Rocky Mountain Data Systems, Denver, Colorado ,1982 pp. 194 – 200.
[4]. Adkins MD, Nanda RS, Currier GF. Arch perimeter changes on rapid palatal expansion. Am J Orthod Dentofacial Orthop1990;97:194-199.
[5]. Motoyoshi M, Hirabayashi M, Shimazaki T, Namura S. Anexperimental study on mandibular expansion: increases in arch width and perimeter. Eur JOrthod2002;24:125–130.
[6]. Sanin C, Savara BS, Thomas DR. Clarkson OD. Arc length ofthe dental arch estimated by multiple regression. J Dent Res1970;49:885.
[7]. Germane N, Lindauer SJ, Rubenstein LK, Revere JH, Isaacson RJ. Increase in arch perimeter due to orthodontic expansion. Am J OrthodDentofacial Orthop1991;100:421–427.
[8]. Hnat WP, Braun S, Chinhara A, Legan HL. The relationship of archlength to alterations in dental arch width. Am JOrthodDentofacial Orthop2000;118:184–188.