Cone-beam computed tomography evaluation of Pont’s index predictability for Malay population in orthodontics

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Abstract

Introduction: In orthodontic treatment, three-dimensional (3D) dental casts has a significant role in diagnosis and treatment planning. The aim of this study was to evaluate Pont’s index predictability in orthodontics. Materials and Methods: Premolar arch width, molar arch width and mesiodistal width of the maxillary incisors were measured three-dimensionally to assess shape of dental arches. The data source was cone beam computed tomography (CBCT) high volumetric data acquisitions from Malay ethnic background. Arch widths were measured and recorded from 53 subjects (32 male and 21 female with the mean age, 25.81), both the maxillary and mandibular arches, to obtain CBCT high volumetric data. All measurements were obtained through CBCT Planmeca Romexis TM Software 2.3.1.R (Helsinki, Finland). Results: Pont’s formula overestimated the upper and lower interpremolar distance, with mean differences of 8.35 ± 3 mm and 12.02 ± 3.20 mm, respectively. Furthermore, the formula overestimated the upper and lower intermolar distance, with mean differences of 7.87 ± 3 mm and 16.14 ± 5.86 mm, respectively. Conclusions: The results indicate that Pont’s index is not practical for use with the Malaysian population since the index overestimated interpremolar and intermolar widths. This raises questions whether the index is a true predictor of arch width measurements.

Key words: Arch width, Cone beam computed tomography, Pont's index, Tooth size

INTRODUCTION

Pont’s index was established in 1909 for the prediction of maxillary dental arch width. It was anticipated from the mesiodistal diameters of the four maxillary incisors.1,2 Arch length, width and depth are the dimensions of the arch. Form and shape of the arch are modified in orthodontic treatment. Various shapes and forms of wires used during the course of orthodontics treatment for changing the arch dimensions.3

In relation to orthodontic investigation, the evidence obtained from dental casts plays a significant role in diagnosis, treatment planning and evaluation.4 Various diagnostic parameters and indices are in use in orthodontics that help in the designing of therapeutic strategies and prediction of the arch dimensions. One of these indices is the Pont’s index proposed in 1909. Pont’s index evaluates the maxillary arch width (the interpremolar or intermolar...
arch widths [IPW or IMW]) depending on the sum of maxillary incisors mesiodistal dimensions. According to Pont, for the accommodation of dentition and relief of crowding, ideal arch is essential.\(^1\) Pont's recruited French population in his study and suggested that this index must be applied for the evaluation, authentication on other populations.\(^\text{[1]}\) The following formula were used in the Pont's prediction for the predicted arch width estimation:

**Interpemolar arch width (IPW) =**
\[
\frac{\text{Sum of the incisal widths (SIW)}}{80} \times 100
\]

**Intermolar arch width (IMW) =**
\[
\frac{\text{Sum of the incisal widths (SIW)}}{64} \times 100
\]

Most studies have shown the nonreliability of the of the Pont's index in the prediction of dental arch width.\(^2,5-13\) Use of premolar and molar indices are rising again as a tool for the evaluation of dental arch development.\(^\text{[5]}\) So far no study has been conducted to evaluate the reliability of Pont's index via three dimensionally cone beam computed tomography (CBCT) acquisitions. Therefore, the aim of this study was to assess the applicability of this index in a Malay population and to compare the results for inter-gender disparities.

**MATERIALS AND METHODS**

All participants provide their written informed consent prior CBCT, and this study was approved by the Ethical Committee of the Hospital Universiti Sains Malaysia (HUSM), which complies with the Declaration of Helsinki. This study was designed and conducted according to the guidelines of Strengthening the Reporting of Observational Studies in Epidemiology (STROBE), and we applied the STROBE checklist in the preparation of this manuscript.\(^\text{[14]}\)

The data source was CBCT high volumetric data from the archives of the School of Dental Sciences, HUSM. Tooth size (incisors) and arch widths were measured and recorded in 53 three-dimensional (3D) CBCT high volumetric data (32 male and 21 female, mean age = 25.81), both in maxilla and mandibular arches. All measurements were obtained through CBCT Planmeca Promax 3D (Helsinki, Finland) [Figure 1].

**Inclusion criteria**
- Age between 20 and 50 years
- At least full dentition in one arch excluding the third molars
- High-quality CBCT volumetric data
- Ethnicity verified from the folder.

**Exclusion criteria**
- Severe crowding
- Excessive spacing
- Radiographic evidence of pathology within the maxilla or mandible
- Periodontal disease
- Retained deciduous teeth
- Fixed orthodontic appliance.

Tooth size and arch width measurements via CBCT acquisitions [Figure 2]:
- Mesio distal widths of maxillary and mandibular incisors were measured from anatomical contact of one tooth to other from occlusal view\(^\text{[15]}\)
- Maxillary IPW were obtained between the distal pits of the maxillary first premolars\(^2\)
- Maxillary IMW were obtained between the central fossae of the maxillary first molars\(^2\)
lower Interpemolar width: were obtained from buccal cusp tip to the buccal cusp tip of the contralateral side.

Lower Intermolar width: were obtained from distal cusp tip to the distal cusp tip of the contralateral side.

**Error study**
Same conditions were avail for all the measurement during the study. A calibrated investigator performed the linear measurements for tooth size and arch width. Dahlberg’s formula was used for method error analysis.\(^\text{[16]}\)

\[
\text{ME} = \sqrt{\frac{\sum (x_1 - x_2)^2}{2n}}; n = \text{number of sample.} 20\% \text{ of CBCT acquisitions were randomly selected for intra-observer errors. The time interval between the first and second reading were approximately 2 weeks.}
\]

**Statistical analysis**
The data were verified and analyzed statistically using IBM SPSS Statistics Version 22.0 (IBM Corp., Armonk, NY, USA) with confidence level set at 5% (\(P < 0.05\)) to
test for significance Student’s t-test was applied to find out for sexual disparities. Correlation co-efficient (r) between measured and calculated arch width were used.

RESULTS

Dahlberg’s formula was used to limit the method-error, which did not exceed 0.05 and 0.032 mm for the linear variables of teeth size and arch width respectively. The collective error for any of the variable was small and measured to be inside suitable limit.[16]

Subject distribution shows mean age 25.81 with slightly more males compared to the females with a total participant of 53 [Table 1]. There were significant difference observed in between the gender in upper and lower first intermolar and upper intermolar measurements with \( P < 0.05 \) [Table 2]. No significant difference found between premolar and molar predicted arch width according to gender in the upper and lower arch width [Table 3]. In relation to gender, there were significant differences observed in the premolar index [Table 4]. Correlation co-efficient (r) between measured and calculated width with significant difference in upper intermolar and lower intermolar were observed [Table 5].

Figure 3 shows the difference between measured and predicted arch width values for upper premolar with the mean difference between measured upper intermolar and upper intermolar distance from Pont’s formula is 8.35 ± 3 mm. Pont’s formula overestimated the upper IPW. Whereas mean difference between measured lower intermolar and lower intermolar distance from Pont’s formula is 12.02 ± 3.20 mm. Pont’s formula overestimated the lower IPW [Figure 4]. Difference in measured calculated and measured upper molar width [Figure 5], the mean difference between

| Table 1: Subject distribution |
|-------------------------------|
| Variables     | Gender | Total |
|---------------|--------|-------|
| n             | 32     | 21    | 53    |
| Mean age      | 27.28  | 23.57 | 25.81 |

| Table 2: Dental arch widths |
|------------------------------|
| Arch width      | Gender | Mean | SD  |
|-----------------|--------|------|-----|
| Sum upper incisors | Male   | 28.17| 2.11|
|                 | Female | 27.79| 1.54|
|                 | Combine| 28.02| 1.9 |
| Sum lower incisors | Male   | 19.94| 1.79|
|                 | Female | 20.44| 1.97|
|                 | Combine| 20.14| 1.86|
| Upper IPW*      | Male   | 44.3 | 2.77|
|                 | Female | 41.95| 3.24|
|                 | Combine| 43.38| 3.16|
| Lower IPW*      | Male   | 38   | 2.91|
|                 | Female | 35.98| 2.26|
|                 | Combine| 37.2 | 2.83|
| Upper IMW*      | Male   | 52.66| 2.81|
|                 | Female | 50.11| 3.33|
|                 | Combine| 51.65| 3.25|
| Lower IMW       | M      | 48   | 4.78|
|                 | F      | 47.01| 7.46|
|                 | Combine| 47.81| 5.94|

\*P < 0.05. IPW: Interpremolar width, IMW: Intermolar width, SD: Standard deviation

| Table 3: Premolar and molar predicted arch width according to gender in the upper and lower arch |
|-----------------------------------------------|
| Pont’s prediction | Gender | Mean | SD  |
|-------------------|--------|------|-----|
| Upper premolar width | Male   | 35.21| 2.63|
|                   | Female | 34.73| 1.93|
|                   | Combine| 35.02| 2.37|
| Lower premolar width | Male   | 24.92| 2.24|
|                   | Female | 25.55| 2.47|
|                   | Combine| 25.17| 2.33|
| Upper molar width  | Male   | 44.01| 3.29|
|                   | Female | 43.41| 2.4 |
|                   | Combine| 31.47| 2.91|
| Lower molar width  | Male   | 31.15| 2.79|
|                   | Female | 31.94| 3.08|
|                   | Combine| 43.78| 2.96|

\*P > 0.05. No significant difference between the genders. SD: Standard deviation

| Table 4: Pont’s index according to gender |
|------------------------------------------|
| Pont’s index | Gender | Mean | SD  |
|--------------|--------|------|-----|
| Upper premolar index* | Male   | 63.7 | 4.96|
|                | Female | 66.49| 4.94|
|                | Combine| 64.81| 5.09|
| Lower premolar index* | Male   | 52.63| 4.93|
|                | Female | 56.97| 5.9 |
|                | Combine| 54.35| 5.7 |
| Upper molar index | Male   | 53.59| 4.35|
|                | Female | 55.66| 4.33|
|                | Combine| 54.4 | 4.42|
| Lower molar index | Male   | 41.99| 5.84|
|                | Female | 44.15| 6.01|
|                | Combine| 42.84| 5.95|

\*P < 0.05. Significant differences noted in the premolar index between the gender. SD: Standard deviation

Figure 2: Cone beam computed tomography measurements of (a) tooth size, (b) arch width
measured upper intermolar distance and calculated upper intermolar distance from Pont’s formula is 7.87 ± 3 mm. Pont’s formula overestimated the upper IMW.

Where the difference between calculated and measured lower molar width the mean difference between measured lower intermolar distance and calculated lower intermolar distance from Pont’s formula is 16.14 ± 5.86 mm. Pont’s formula overestimated the lower IMW [Figure 6].

DISCUSSION

This study was conducted to evaluate the validity of Pont’s index via CBCT high volumetric images in estimating the dental arch width depending on the sum of mesiodistal dimensions of maxillary incisors. It was found that Pont’s index overestimated the intermolar and intermolar widths in most of Malaysians.[2]

Pont’s index is simple method that provides valuable information in the treatment plan. However, use of this index is still controversial. Some professionals support the use of Pont’s index for the prediction of arch widths.[17-19] While others believe that it should not be used for the prediction of arch dimensions.[2,6-9,20] As Pont’s index is the average ratio hence it could not be used as a true predictor of the arch width for each individual. Thus mechanical arch development may not be steered by Pont’s index.[21]

In this study, it was found that Pont’s index over predicts the arch width. Nimkarn also reported the overestimation of the Pont’s index for desired arch by an average 2.5 mm.[9] Reliability and clinical applicability for the diagnosis and therapeutic strategies of Pont’s index is uncertain.[22] A study conducted in Nepal showed low correlation co-efficient between the arch widths, that is, R-values ranging from 0.07 to 0.29. It was concluded that Pont’s index is not a reliable parameter for the determination of arch width for Nepali population.[12]

Findings of Agnihotri are at variance of the above mentioned studies, who reported that statistically significant correlation between the combined maxillary incisor widths and the maxillary IMW and IPW.[17] He found a corrected index of 81.66 in the premolar and 65.44 in the molar region. While the corrected index in this study was 84.9 in the premolar region and 65.7 in the molar region. However, there were no significant differences between the Pont’s index and the mean values

Table 5: Correlation co-efficient (r) between measured and calculated width

| Arch width | Co-efficient of correlation | P  |
|-----------|----------------------------|----|
| Upper IPW | 0.408                      | 0.002** |
| Lower IPW | 0.238                      | 0.087 |
| Upper IMW | 0.252                      | 0.69  |
| Lower IMW | 0.272                      | 0.049* |

*IPW: Interpremolar width, IMW: Intermolar width, **p ≤ 0.01 and *p ≤ 0.05

Figure 3: Difference between measured and predicted arch width values for upper premolar

Figure 4: Mean difference of lower premolar measured and calculated arch width

Figure 5: Difference in measured calculated and measured upper molar width

Figure 6: Difference between calculated and measured lower molar width
in Tumkur population. Pont’s index cannot be used as a reliable predictable tool for in clinical settings for planning the treatment modalities. Treatment strategies cannot be relied upon simple mathematical calculations; it should be based on the biological rationale. An assessment of the facial profile and soft tissues, future growth status, determination of the Angle’s classification, relationship of upper and lower jaws to one another, and the midline etc. are possible other parameters which need to be taken into consideration of arch orthodontic expansion. Possible explanation of the variation of the results may be based on the racial differences. It is suggested that some polygenic inheritance controls the maxillary dimensions and the Pont’s index may vary across different populations and races. Such prediction index cannot be relied without consideration of extra oral features. As for the reliability of such analysis, investigations on innumerable racial groups considered their population craniofacial features too.

**CONCLUSION**

- The results show that Pont’s index is practically not applicable for the Malaysian population
- The Pont’s index overestimated IPW and IMW
- Prediction of arch width clinically by the use of Pont’s index is questionable.

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**Conflicts of interest**

There are no conflicts of interest.

**REFERENCES**

1. Pont A. Der zahn-index in der orthodontie. Zahnärztliche Orthop 1909;3:306-21.
2. Purmal K, Alam MK, Moganadass DD, Zakariat NN, Cheong NW. The application and correlation of Pont’s index to the facial framework of three main ethnic groups in Malaysia. Aust Orthod J 2013;29:34-42.
3. Anwar N, Fida M. Variability of arch forms in various vertical facial patterns. J Coll Physicians Surg Pak 2010;20:565-70.
4. Hayashi K, Uechi J, Mizoguchi I. Three-dimensional analysis of dental casts based on a newly defined palatal reference plane. Angle Orthod 2003;73:539-44.
5. Dalidjan M, Sampson W, Townsend G. Prediction of dental arch development: An assessment of Pont’s index in three human populations. Am J Orthod Dentofacial Orthop 1995;107:465-75.
6. Joondeph DR, Riedel RA, Moore AW. Pont’s index: A clinical evaluation. Angle Orthod 1970;40:112-8.
7. Worms FW, Speidel TM, Isaacson RJ, Meskin LH. Pont’s index and dental arch form. J Am Dent Assoc 1972;85:876-81.
8. Lew K. The effect of variations in the mandibular plane angle on the Pont’s index. Funct Orthod 1991;8:24-7.
9. Nimkarn Y, Miles PG, O’Reilly MT, Weyant RJ. The validity of maxillary expansion indices. Angle Orthod 1995;65:321-6.
10. Oroudbazary M, Zafarmand AH, Madani A, Oroudbazary A. Comparison of Pont’s and Korkhaus indices at different populations. Hellenic Orthod Rev 2007;10:67-74.
11. Al-Omari IK, Duaibis RB, Al-Bitar ZB. Application of Pont’s index to a Jordanian population. Eur J Orthod 2007;29:627-31.
12. Hong Q, Tant J, Koirla R, Lina Y, Shimizu T, Nakano K, et al. A study of Bolton’s and Pont’s analysis on permanent dentition of Nepalese J Hard Tissue Biol 2008;17:55-62.
13. Alvaran N, Roldan SI, Buschang PH. Maxillary and mandibular arch widths of Colombians. Am J Orthod Dentofacial Orthop 2009;135:649-56.
14. Vandenbroucke JP, Von Elm E, Altman DG, Gøtzsche PC, Mulrow CD, Pocock SJ, et al. Strengthening the Reporting of Observational Studies in Epidemiology (STROBE): Explanation and elaboration. PLoS Med 2007;147:W163-94.
15. Alam MK, Shahid F, Purmal K, Ahmad B, Khamis MF. Bolton tooth size ratio and its relation with arch widths, arch length and arch perimeter: A cone beam computed tomography (CBCT) study. Acta Odontol Scand 2014;72:1047-53.
16. Houston WJ. The analysis of errors in orthodontic measurements. Am J Orthod 1983;83:382-90.
17. Agnihotri G, Gulati M. Maxillary molar and premolar indices in North Indians: A dimorphic study. Int J Biol Anthropol 1994;55:119-25.
18. Gupta DS, Sharma VP, Aggarwal SP. Pont’s index as applied on Indians. Angle Orthod 1979;49:269-71.
19. Stifter J. A study of Pont’s, Howes’, Rees’, Neff’s And Bolton’s analyses on class I adult dentitions. Angle Orthod 1958;28:215-25.
20. Sergl HG, Reinhardt R, Zentner A, Schmidt J. A dental arch index related to tooth size and facial breadth. Fortsch Kieferorthop 1994;55:119-25.
21. Ruth MK, Fida M. Applicability of Pont’s index in orthodontics. J Coll Physicians Surg Pak 2014;24:256-60.
22. Al-Sarraf HA, Abdul-Mawjood AA, Al-Sayagh NM. Re-assessment of Pont’s index in class I normal occlusion. Al-Rafidain Dent J 2013;6:1-5.
23. Sridharan K, Madhusudhan V, Srinivasa H, Mahobia Y, Shailesh S. Evaluation of validity of Pont’s analysis in Tumkur population. J Dent Sci Res 2011;2:41-9.
24. Alam MK, Purmal K, Begum S, Saifuddin M, Sikder M. Fallibility of Pont’s index in a Bangladeshi population. Orthod Waves 2014;73:61-7.
25. Alam MK, Purmal K, Cheong NW. Pont’s index is not exact science: A reappraisal. Int Med J 2013;20:204-7.