ABSTRACT

Background: Malocclusion in the vertical and sagittal planes is easy to observe whereas it is difficult to diagnose malocclusion in the transverse plane. There are yet no criteria defining a normal transverse occlusion.

Aim: The aim of this study was to identify a ratio that defines a normal transverse occlusion.

Study Design: This was a retrospective study.

Materials and Methods: A total sample of 151 maxillary dental models (M = 55, F = 96) in the age range of 12–16 years were randomly selected, with 73 models in control group and 78 in the study group. All the models were mixed up and given to an operator for the measurement of intercanine width (ICW) and inter-palatal molar width (IPMW).

Statistical Analysis Used: The data were statistically analyzed using SPSS software version 16.0. Chi-square test was performed to test the statistical significance difference between the groups at \( p \leq 0.05 \).

Results: Nearly 98.60% of normal arches were found to have an IPMW to ICW ratio of 1:1 ± 0.05. On further analysis, it was found that when IPMW ≥ 37.45 mm, then the case may be considered to have normal arches, and if the ratio between IPMW to ICW is 1.15:1 ± 0.05 or more and IPMW is <34.92 mm, then the case may be identified as deficient arch.

Conclusion: The IPMW-to-ICW ratio can be used to differentiate deficient and normal arches. This hypothesis (Banker’s hypothesis) is an easy and noninvasive method, using only two parameters, developed to help clinicians in identifying normal transverse dimension.

Key words: Broad arches, deficient arches, maxillary transverse deficiency, narrow arches, normal arches, normal transverse dimension

The dental arch forms are of considerable importance to the orthodontists as they aid in treatment planning, esthetics, and teeth stability.\(^1\) Deficiency in the maxillary arch width leads to constriction of maxilla, and it is considered to be one of the most common skeletal problems in the craniofacial region.\(^2\) Diagnosing a case of transverse deficiency is subjected to debate among orthodontists, as there is no one agreed on a set of diagnostic criteria available. Traditional diagnostic techniques such as transpalatal tooth-to-tooth measurement, posteroanterior film measurement, and posterior crossbite visual assessment have been applied to identify transverse deficiency cases.

The transverse dimension of maxilla is determined by anterior arch width measured through intercanine distance and posterior arch width through intermolar distance. Some authors\(^3,4\) have also used interpremolar distance to assess the transverse dimension of maxilla. Arch width is one of the parameters in deciding the arch form, which plays a key role in creating the optimum esthetics, functional occlusion, stability, and well-finished results from an orthodontist’s

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point of view. Broad arches are implicated in having stable, well-balanced, functional occlusion. Hence, there is a need for a delineation of broad or normal arches from narrow or deficient arches based on arch width. Several methods have been proposed to evaluate the transverse dimension: McNamara’s hypothesis,[2] Pont’ formula,[3] Schwartz’s analysis (Schwarz et al., 1966), Korkhaus analysis, Hayes’s(6) finger palpation technique, Rickett’s method(7) using cephalometric analysis, Howe’s index,(8) Moyer’s index (Profitt, 2000), and transpalatal width measurement index by Howe et al.(9) However, each method has its own drawbacks.

Prior to the start of our study, we found that in majority of the normal maxillary arches, the cusp tip of the canine was usually in line with the palatal surface of the first molar [Figure 1]. Hence, we hypothesized that the interpalatal molar width (IPMW), the intercanine width (ICW), and its ratio can ascertain the transverse dimension and so we made an attempt to quantify the arch form using this ratio. In this study, we intended to utilize the maxillary arch to predict the arch form, only by using the ICW and IPMW as parameters. The authors wanted to test their hypothesis that if the ratio between IPMW to ICW is equal to 1:1 ± 0.05, the case may be considered to have normal arches. This hypothesis is henceforth referred in this article as Banker’s hypothesis. With the advent of advanced diagnostic technology such as cone beam computed tomography, a more precise diagnosis of maxillary transverse deficiency (MTD) is possible nowadays, though it is highly expensive and technique sensitive. A normal sagittal dimension can be defined through Angle’s classification as Class I and normal vertical dimension can be defined as a 2 mm overbite; however, there is no definite parameter to define the normal transverse dimension. Through this study, we made an attempt to identify those parameters which can define the normal transverse dimension using limited parameters and tools.

**MATERIALS AND METHODS**

This retrospective study was approved by independent Ethics Committee. The aim, objectives, and the possible outcomes of the study were explained to all the participants and informed consent was obtained from them. A total sample of 151 maxillary dental models (M = 55, F = 96) in the age range of 12–16 years were selected, with 73 models in control group and 78 in study group. Inclusion criteria for study group were patients having dental characteristics which included maxillary arch width deficiency, a V-shaped palate with a deep vault with either a unilateral or bilateral crossbite or crowding, and being advised maxillary expansion as part of their comprehensive treatment plan. None of the patients had cleft lip, cleft palate, or any other craniofacial syndrome nor had undergone previous orthodontic treatment. The inclusion criteria for all the participants in the control group were well-aligned and normal arches, no crowding or spacing present, no severe attrition, no clinically evident interproximal caries, no previous orthodontic treatment or prosthodontic treatment, and no history of trauma. Pretreatment maxillary dental models of 78 patients (M = 30; F = 48) in the age group of 12–16 years, treated by maxillary expansion, were obtained from an orthodontic clinic. These models formed the “study group” samples. The control group consisted of 73 samples from 100 participants taken from a nearby school, age- and sex-matched with the study group (M = 25; F = 48), again in the age group of 12–16 years, and who were deemed to have nearly perfect occlusion and normal arches. To reduce selection bias, these models were shown to three senior orthodontic practitioners. Only those models that all three of them agreed had near ‑perfect occlusion with normal arches were chosen. Cohen’s Kappa statistical analysis tool was used to check that such an agreement is not by chance (at significance level 0.05). Cohen’s Kappa score was 0.79 and it was statistically significant. A total of 73 models were selected by them and they formed the “control group” samples. Finally, we had 78 maxillary models in the study group and 73 maxillary models in control group. All these 151 dental models, consisting of study group models with deficient arches and control group models with normal arches, were mixed up and given to a blinded operator for measurements. All the arch dimensions measurements were made on the models using an electronic digital sliding caliper (Forbes 2004, Model number 111-302).

The following linear parameters were considered in the measurement [Figure 2].

**Intercanine width (mm)**
The ICW is measured from tips of the right and left canines. In case where the canines are out of arch, measurements were taken from the center of the alveolar arch in the canine region.

**Interpalatal molar width (mm)**
The interpalatal molar distance is measured from where the palatal groove ends on the palatal aspect of the first right and left molars.

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**Figure 1:** Tangential line from the canine cusp tip in line with the height of convexity on the palatal surface of the first molar
Sum of incisors (mm)
The mesiodistal widths of all the four upper incisors were calculated and summed up.

Linear distance between canines and interpalatal molars was measured. Then, the ratio between IPMW and ICW was calculated. Based on the hypothesis of the authors, all the dental models were divided into two categories such as narrow or deficient arches (B deficient) and normal arches (B normal).

Banker’s hypothesis = If ratio between IPMW: ICW = 1:1 ± 0.5, it is a normal arch

To compare our hypotheses with other commonly used methods, all the dental models were also subjected to Pont’s analysis and categorized into p-deficient (narrow according to Pont’s analysis) and p-normal (broad according to Pont’s analysis).

Pont’s analysis = if the inter premolar width ≤SI × 100/80, it is a deficient arch
if molar width ≤SI × 100/64, it is a deficient arch

Where, SI = Sum of incisor. Similarly, McNamara’s criteria were also taken into consideration, and the models were categorized into M-deficient (narrow according to McNamara) and M-normal (broad according to McNamara).

McNamara’s criteria = maxillary arches with IPMW ≤31 mm = deficient arch
maxillary arches with IPMW ≥36 mm = normal arches

IPMW and ICW were measured on blinded models, and the ratio between IPMW and ICW was calculated. After that, Banker’s hypothesis, Pont’s analysis, and McNamara’s criteria were applied. The models were bifurcated into two groups; deficient and normal arch according to each analysis. Then, blinding from the models was removed, and the result of the analysis was compared with the study and control models in the actual situation.

Statistical analysis
Descriptive statistics (mean and standard deviation) and hypothesis tests were performed using SPSS software version 16.0 (IBM, Armonk, NY). All the parameters of arch dimension were repeated three times with a time interval of 1 week by the same examiner to eliminate possible error in the measurements. Then, the mean of the repeated measurements was taken. To assess intraexaminer reliability, the operator measured fifty randomly selected casts at two different times. Interclass coefficient of correlation was performed to test the reliability of data. Cross tabulations were made for the diagnosis of MTD for each of the above-mentioned groups and they were compared with the actual situation. Chi-square test was performed to test the statistical significance difference between the diagnosis of Pont’s, McNamara, and our study, at \( p \leq 0.05 \).

RESULTS

Interclass coefficient correlation results mentioned in Table 1 show that data are reliable to perform further statistical analysis. The mean ICW and IPMW in the study and control group are mentioned in Table 2. From Table 3, it can be observed that out of the 78 study models, the number of deficient arches identified by Pont’s, McNamara, and Banker’s hypothesis was 76 (97.43%), 7 (8.97%), and 13 (16.6%), respectively. Similarly, out of the 73 control models, the number of well-formed arches identified by Pont’s, McNamara, and Banker’s hypothesis was 50 (64.10%), 65 (89.04%), and 72 (98.60%), respectively. There is no statistically significant difference of Pont’s, McNamara, and Banker’s hypothesis in the assessment of transverse dimension as compared with the actual situation. This suggests that the assessment of transverse maxillary dimension is possible by all these methods.

Table 1: Intra class coefficient of correlation

| Parameters (mm)                  | \( R^2 \) |
|----------------------------------|-----------|
| Inter-canine width (ICW)         | 0.999     |
| Inter-palatal molar width (IPMW) | 0.998     |
| Sum of incisors (SI)             | 0.969     |

Table 2: Mean±SD values of ICW and IPMW for study and control groups

| Group       | Inter Canine Width (ICW) (mm) | Inter Palatal Molar Width (IPMW) (mm) |
|-------------|-------------------------------|-------------------------------------|
| Study       | 30.61±2.05                    | 34.08±2.02                          |
| Control     | 35.14±1.29                    | 38.15±1.62                          |
and furthermore, Pont’s analysis is more accurate in the diagnosis of study group having MTD, i.e. 97.43%, whereas McNamara (89.04%) and Banker’s analyses (98.6%) are more accurate in the diagnosis of control group, having normal arches.

**DISCUSSION**

The contraction or expansion of maxillary arch, especially at the canine or molar regions, requires thorough pretreatment analysis and planning. An unplanned management produces instability in those regions posttreatment. A good, well-balanced occlusion is often dependent on treating all the three components of a malocclusion, i.e. vertical, sagittal, and the transverse dimensions. Even with all the various proposed methods, there is no single criterion onto which every clinician can rely. The assessment of MTD is very subjective. Hence, this study was undertaken to find a simple and preliminary diagnostic method to assess the dimension of maxilla in the transverse plane. We used only two parameters in our study, i.e. ICW and the IPMW, which can be measured easily by the clinicians as a chairside technique and help them to plan out their treatment regimen for the patients. The primary findings of this study are that though all the three methods could identify deficient and normal arches, Pont’s analysis was more accurate in identifying deficient arches as compared to Banker’s hypothesis and McNamara’s criteria. Whereas Banker’s hypothesis and McNamara’s criteria are more accurate in identifying well-formed arches as compared to Pont’s analysis. Banker’s hypothesis is more accurate (98.6%) than McNamara’s criteria (89.04%) in identifying well-formed arches.

According to Banker’s hypothesis, normal arches will have an IPMW: ICW ratio of 1.1 ± 0.5 (P ≤ 0.05). Banker’s hypothesis could identify 72 out of 73 models from the control group consisting of normal arches. On analyzing further, it was also found that if the ratio between IPMW: ICW ≥ 1.15:1, the models can be identified as having deficient arches.

Out of the 78 models in the study group, Pont’s analysis could identify 76 cases as having deficient arches. Hence, Pont’s analysis was more efficient (97.43%) in diagnosing the study group. Pont’s analysis was not efficient in identifying the control group since it could identify only 50 out of the 73 control group models. These findings are in agreement with those reported by another investigator. Results of McNamara’s criteria are similar with that of our study. The average transpalatal molar width in Banker’s hypothesis is 38.15 ± 1.62 mm in the control group. McNamara stated that maxillary arch with a transpalatal width of 36–39 mm is considered to be adequate for dentition of average size without crowding or spacing whereas maxillary arches <31 mm in width may be crowded and need orthopedic or surgically assisted expansion. In our study, an average of 34.08 ± 2.02 mm IPMW was seen in the study group consisting of the narrow arches. This was 3.08 mm more than that suggested by McNamara. When these results were statistically analyzed, it was found that both the studies, i.e., McNamara and Banker’s hypothesis are efficient in the diagnosis of control group. In this study, the average IPMW was 34.08 ± 2.02 mm in the cases of study group and 38.15 ± 1.62 mm in the cases of control group which was in accordance with the study done by Howe et al. In their study, the IPMW of maxillary arch in males averaged 37.4 mm in the noncrowded group and 30.8 mm in the crowded group which was 6.1 mm larger than in the crowded group. The authors have used a method which is a very simple, easy, and chairside technique. It can be used by the clinicians on a preliminary basis to plan their treatment regimen. This method will help identify cases having normal arches and rule out the cases requiring expansion as a part of their comprehensive treatment plan. It is advised that the final diagnosis should always be confirmed by using radiographs.

**Clinical significance**

- It helps in identifying cases requiring maxillary expansion by differentiating normal and deficient maxillary arches
- Provides a benchmark for achieving proportionate arch widths after treatment.

**CONCLUSION**

- Among all the three groups, Banker’s hypothesis and McNamara’s criteria were efficient in the diagnosis of control group consisting normal arches whereas Pont’s analysis was more efficient in the diagnosis of the study group consisting of deficient arches. This study was most efficient (98.60%) in the diagnosis of normal arches

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**Table 3: Cross tabulation for Pont’s, McNamara and our study in assessment of maxillary transverse dimension**

| Group   | Pont’s P Deficient | Pont’s P Normal | McNamara’s M Deficient | McNamara’s M Normal | McNamara’s Not Defined | Banker’s B Deficient | Banker’s B Normal | Total |
|---------|--------------------|-----------------|------------------------|---------------------|------------------------|----------------------|-------------------|-------|
| Study   | 76 (97.43%)        | 2 (2.56%)       | 7 (8.97%)              | 15 (19.23%)         | 56 (71.79%)            | 13 (16.6%)           | 65 (83.33%)       | 78    |
| Control | 23 (29.48%)        | 50 (64.10%)     | 0 (Nil)                | 65 (89.04%)         | 8 (10.95%)             | 1 (1.36%)            | 72 (98.6%)        | 73    |

Chi Squared test

***P=0.001, ****P=0.0001

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• On further analysis, it was found that if the ratio between IPMW width to ICW is equal to 1:1 ± 0.05 and IPMW is more than 37.45 mm, the case may be considered to have normal arches, and if the ratio between IPMW to ICW is 1.15:1 ± 0.05 or more and IPMW is <34.92 mm, the case may be identified as deficient arch.

• A 1:1 ratio of IPMW to ICW is a simple, easy to measure, chairside diagnostic aid. Clinicians can aim to achieve this ratio at the end of treatment for achieving well-proportioned normal arches.

• This technique does not require any expensive equipment or exposure to extra radiation.

• There is scope of future research in this area on a larger sample size and gender-specific ratio.

Limitations of the study

• One of the limitations of this study was this ratio cannot be applied to cases which are constricted simultaneously in both anterior and the posterior regions. However, in such cases, the posterior teeth would be in crossbite and this feature itself is one of the criteria for MTD.

• There was no discrimination done based on gender in our study.

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Conflicts of interest

There are no conflicts of interest.

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