The Effect of First Permanent Tooth Eruption on Dental Arch Dimension

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Abstract

Background: Crowding is one of the most prevalent types of malocclusion as well as a major problem in clinical orthodontics. It is essential to know the cause of crowding in order to achieve a better treatment.

Objectives: A longitudinal analysis of arch dimension changes in late primary and early mixed dentition periods in children was designed and investigated the effect of eruption of precedence on the arch size in the samples under study.

Methods: This longitudinal study was carried out on 32 children aged 5.5 - 6.5 years who had no erupted permanent dentition. Impression was taken and the arch perimeter, depth and width as well as tooth size were measured by a digital calliper and a brass wire on casts. After eruption of the first permanent tooth, the second impression was taken; the above-mentioned parameters were measured on the second casts. Data were analysed by ANOVA test.

Results: Four pattern of eruption of precedence were as follows: maxillary 1st molar, mandibular incisors, Mandibular 1st molars and simultaneous eruption of maxillary and mandibular 1st molars. With eruption of mandibular central incisors, inter canine width and overjet increased by 0.81 and 0.27 mm, respectively. The mandibular arch perimeter increased by 2.25 mm with simultaneous eruption of maxillary and mandibular permanent first molars. The maxillary arch perimeter increased by 1.25 mm and 1.50 mm with eruption of maxillary first molars and simultaneous eruption of maxillary permanent first molars, respectively.

Conclusions: Eruption precedence had a significant effect on changing mandibular inter canine width, maxillary arch perimeter, mandibular arch perimeter and overjet.

Keywords: Arch Perimeter, Arch Width, Arch Depth, Primary Dentition, Permanent Dentition

1. Background

Crowding is one of the most common malocclusions and an important problem in clinical orthodontics (1). White and Barrow reported the prevalence of mandibular incisor crowding to be 14% at age 6 and 51% at age 14 (2). Also, prevalence of dental crowding is variable among different populations as the study of Normando et al. showed the prevalence of dental crowding was significantly higher in Arara-Laranjal than Arara-Iriri population (3).

Mandibular anterior crowding in mixed dentition period makes the children, their parents and paediatric dentists worried (4). Although the role of genetic and environmental factors in aetiology of crowding is still under question, new evidence suggests that dental crowding, which has been caused by over processed modern foods, is a common malocclusion in post-industrial humans (5). Thus, knowledge of the factors involved in crowding and its participation is of great significant in achieving a better treatment. Mandibular anterior crowding is defined as the difference between tooth size and arch size, which causes malocclusion (6). Crowding of incisors is not merely due to tooth-arch size discrepancy and more variables are involved in this difference (7).

According to Linden classification (8), crowding is divided into three types based on its causes: (1) hereditary disorder in harmony between tooth size and arch length; (2) environmental factors like dental caries and extraction; (3) delay type which is seen after puberty.

Barber (9) has introduced some of these environmental factors, and believes that crowding can be due to unusual muscular forces, ectopic eruption pattern and occlusal forces, which cause mesial displacement and loss of arch length and consequently dental caries. Lavelle (10) has also proposed that age and race play a role in crowding. Some researchers are in agreement with the theory of the
presence of relationship between tooth size and arch size in crowding (1). That is why no study has been conducted in this regard to obtain a closer connection between these two variables. On the other hand, because crowding is seen in many patients even after orthodontic retention periods, this issue has probably more details and influential factors that need to be investigated in future research and maybe one of the factors that could influence crowding is arch changes related to the eruption precedence of permanent teeth.

2. Objectives

Since crowding is multifactorial, this study was aimed to explore the effect of eruption precedence of the first permanent teeth on the arch size changes and developing crowding.

3. Methods

The study protocols were approved by the Regional Committee for Medical Research Ethics (Code #5076).

After making arrangements with Social Welfare Department of Saveh city, taking letters of permission for Kasra and Minoo kindergartens and taking informed consent from the children’s parents, 81 children aged 5.5 - 6.5, including 42 girls and 39 boys, who had no erupted permanent tooth were included in this study.

The inclusion criteria consisted of presence of all primary dentition, being in late primary dentition period, absence of dental restorations or caries that had caused degradation of marginal ridge and absence of loose primary teeth. A form was also prepared to record the data. Samples being selected, each child was given a code, and personal information was recorded in the first part of the form with a specific code. Then, intraoral examinations were performed, and presence or absence of spacing and crowding, type of occlusion and presence of tooth abrasion were analysed, and the obtained data were recorded in the second part of the form. Next jaw impressions were taken and wax bite was also registered.

Since taking the children’s impression with alginate was difficult in kindergartens, putty impression material (Speedex, Swiss) was chosen. The impression was checked for absence of bubble and accurate recording of all the teeth. Also, a part of vestibule depth was analysed. The impressions which did not fulfil the above-mentioned requirements were repeated again. The impressions were disinfected by spray (Deconex, Switzerland). Then, casts were prepared with type IV plaster (ERNST, Germany) because of high resistance against abrasion, scratch and damage. The quality of casts was evaluated. The intercanine width from the tip of primary canine cusps and inter molar width from the central fossa of primary second molars were measured by a digital calliper (INSIZE, USA, 0.01). A brass wire was used to measure the arch perimeter of jaws.

The wire was extended in a curve line from distal surface of second primary molar on one side around the tooth arch on the contact points and incisal edges to the distal surface of primary second molar of the other side. Then, the wire was placed on a millimeter ruler and perimeter size was recorded. The overbite and overjet values of the casts prepared from the first stage impressions were calculated by probe. To measure the length or depth of arches, a line tangent to the distal surfaces of primary second molars was drawn, and a line perpendicular to this line was drawn from the central incisors. The distance between the intersection of these two lines and the midpoint of central incisors was recorded by a digital caliper as the arch length. Each measurement was done twice in two different times, and the mean value obtained was recorded as the final measurement. The children under study were examined once a month until their first permanent tooth was fully erupted. Following the full eruption of the tooth, the second putty impression (Speedex, Swiss) was taken. The casts were prepared with Moldano plaster the same as the first stage and were trimmed by orthodontic method. Then, the above-mentioned parameters were measured on them, and the obtained data were recorded in the given form. From 81 children included in the study, 32 of them, including 18 girls and 14 boys were subjected to second stage impression taking, and the rest of them were lost because the study was lengthy.

4. Results

From 81 children included in the study, 32 children (18 girls and 14 boys) experienced two-stage impression technique, and the rest of samples were lost because of the longitudinal nature of the study.

The data obtained from the measurement of casts were analysed statistically. Description of data is presented in details in the Tables 1-3.

As for the eruption precedence, the first permanent tooth erupted in four different modes: 11 cases with eruption of mandibular central incisors, 5 cases with eruption of maxillary first molar, 9 cases with eruption of mandibular first molar and 7 cases with simultaneous eruption of maxillary and mandibular first molars. Figure 1 illustrates the frequency of eruption precedence of central incisors or first molars in the studied samples.
Further, the changes of variables with different eruption precedence (central incisor or first molar) were analysed by ANOVA, whose results are shown in Table 4. The findings showed eruption precedence had a significant effect on mandibular inter canine width, maxillary arch perimeter, mandibular arch perimeter and overjet.

The inter-canine width was significantly higher in the group with eruption of mandibular central incisors than the other three groups. With eruption of mandibular central incisors, inter-canine width increased by 0.81 mm. The overjet significantly increased by 0.27 mm in the group with eruption of mandibular central incisors. The mandibular arch perimeter was significantly higher in the group with simultaneous eruption of maxillary and mandibular permanent first molars than the other three groups. With simultaneous eruption of maxillary and mandibular permanent first molars, the mandibular arch perimeter in-

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**Table 1. Description of the Arch Sizes by mm (N = 32)**

|                          | Minimum | Maximum | Mean ± SD |
|--------------------------|---------|---------|-----------|
| Inter molar width.man.1  | 31.48   | 40.18   | 33.41 ± 1.66 |
| Inter molar width.man.2  | 32.37   | 40.86   | 34.04 ± 1.73 |
| Inter molar width.max.1  | 34.13   | 46.09   | 38.33 ± 2.08 |
| Inter molar width.max.2  | 34.28   | 46.34   | 38.89 ± 2.04 |
| Inter canine width.man.1 | 20.22   | 25.48   | 22.77 ± 1.45 |
| Inter canine width.man.2 | 20.54   | 26.00   | 23.28 ± 1.56 |
| Inter canine width.max.1 | 24.53   | 33.15   | 28.61 ± 1.77 |
| Inter canine width.max.2 | 24.67   | 33.31   | 28.99 ± 1.77 |
| Over bite.1              | -4.00   | 3.00    | 1.25 ± 1.39  |
| Over bite.2              | -2.00   | 3.00    | 1.46 ± 1.08  |
| Over jet.1               | 0.00    | 4.00    | 1.76 ± 0.72  |
| Over jet.2               | 0.00    | 4.00    | 1.75 ± 0.75  |
| Arch perimeter.man.1     | 62.50   | 79.50   | 71.12 ± 1.89 |
| Arch perimeter.man.2     | 63.00   | 81.00   | 72.03 ± 1.97 |
| Arch perimeter.max.1     | 71.00   | 87.50   | 77.49 ± 1.81 |
| Arch perimeter.max.2     | 71.00   | 88.00   | 78.09 ± 1.73 |
| Arch depth.man.1         | 20.07   | 28.22   | 24.20 ± 1.63 |
| Arch depth.man.2         | 20.68   | 28.17   | 24.67 ± 1.58 |
| Arch depth.max.1         | 22.65   | 30.01   | 27.16 ± 1.61 |
| Arch depth.max.2         | 22.85   | 30.90   | 27.61 ± 1.69 |

Abbreviations: ‘max, maxilla; man, mandible; 1, first stage data in primary dentition period; 2, second stage data after eruption of the first permanent tooth

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**Table 2. Description of Arch Size Changes After Eruption of the First Permanent Tooth**

|                          | Mean   | Std. Deviation | Std. Error |
|--------------------------|--------|----------------|------------|
| ‘Diff.inter molar width.man’ |       |                |            |
| Lower central            | 0.54   | 0.38           | 0.21       |
| Lower first molar        | 0.80   | 0.38           | 0.20       |
| Upper first molar        | 0.12   | 0.50           | 0.25       |
| Both lower and upper first molar | 0.97   | 1.41           | 1.00       |
| ‘Diff.inter molar width.max’ |       |                |            |
| Lower central            | 0.45   | 0.41           | 0.21       |
| Lower first molar        | 0.46   | 0.26           | 0.06       |
| Upper first molar        | 0.99   | 0.46           | 0.23       |
| Both lower and upper first molar | 0.91   | 0.98           | 0.69       |
| ‘Diff.inter canine width.man’ |       |                |            |
| Lower central            | 0.81   | 0.50           | 0.25       |
| Lower first molar        | 0.40   | 0.29           | 0.07       |
| Upper first molar        | -0.04  | 0.02           | 0.01       |
| Both lower and upper first molar | 0.66   | 0.12           | 0.09       |
| ‘Diff.inter canine width.max’ |       |                |            |
| Lower central            | 0.47   | 0.30           | 0.09       |
| Lower first molar        | 0.34   | 0.38           | 0.09       |
| Upper first molar        | 0.27   | 0.45           | 0.22       |
| Both lower and upper first molar | 0.30   | 0.67           | 0.47       |
| ‘Diff.over bite’          |        |                |            |
| Lower central            | 0.50   | 0.67           | 0.20       |
| Lower first molar        | 0.03   | 0.12           | 0.03       |
| Upper first molar        | 0.25   | 0.50           | 0.25       |
| Both lower and upper first molar | 0.00   | 0.00           | 0.00       |

Abbreviations: ‘man, mandible; max, maxilla; diff, difference
| Table 3. Description of Arch Size Changes After Eruption of the First Permanent Tooth |
|---------------------------------|-----------------|-----------------|-----------------|
|                                | Mean            | Std. Deviation  |
| *Diff. overjet*                 |                 |                 |
| Lower central                   | 0.27            | 0.46            |
| Lower first molar               | -0.16           | 0.36            |
| Upper first molar               | 0.00            | 0.40            |
| Both lower and upper first molar| -0.50           | 0.70            |
| **Diff.arch perimeter**         |                 |                 |
| Lower central                   | 0.68            | 0.64            |
| Lower first molar               | 0.39            | 0.58            |
| Upper first molar               | 0.50            | 0.00            |
| Both lower and upper first molar| 2.25            | 0.35            |
| **Diff.arch depth**             |                 |                 |
| Lower central                   | 0.33            | 0.44            |
| Lower first molar               | 0.62            | 0.57            |
| Upper first molar               | 0.22            | 0.19            |
| Both lower and upper first molar| 1.50            | 0.70            |
| **Diff.arch depth**             |                 |                 |
| Lower central                   | 0.76            | 1.40            |
| Lower first molar               | 0.44            | 0.52            |
| Upper first molar               | 0.70            | 0.51            |
| Both lower and upper first molar| 0.92            | 0.57            |

| Abbreviations: | man, mandible; max, maxilla; diff, difference |

increased by 2.25 mm. The maxillary arch perimeter was significantly higher in the group with eruption of maxillary first molar and the group with simultaneous eruption of maxillary and mandibular permanent first molars than the other two groups. With eruption of maxillary first molar, arch perimeter increased by 1.25 mm, and with simultaneous eruption of maxillary and mandibular permanent first molars, the arch perimeter increased by 1.50 mm.

5. Discussion

A challenging issue in orthodontics is anterior dental crowding before and even after orthodontic treatment.

Lopez-Areal et al. compared crowding rate in 51 patients before treatment, after treatment and after retention period and found that maxillary incisor crowding and arch length change recurred over time (11).

Although crowding is the most common type of malocclusion (12, 13), presence of short period of mandibular anterior teeth crowding has been accepted as a normal developmental stage (14). This crowding is compensated by increased inter-canine width, labial position of permanent incisors relative to primary incisors and backward movement of canine to primate space (14). Aminabadi et al. conducted a study on 105 children aged 5 - 7.5 years whose mandibular permanent incisors had erupted on the lingual side of primary incisors. They showed that considering all the three groups with balanced space, additional space and shortage of space as a whole, 70.45% of them lost their primary incisors without any trouble and only 14.8% needed extraction of primary incisors (15). Incisor crowding is observed in both adolescents and adults (16). Jonsson et al. observed a significant increase in mandibular anterior crowding over a 25-year follow-up of patients (17).

Warren et al. (1) analysed the relationship of tooth size with arch length in two periods in a geographical region among a similar number of girls and boys and reported that maxillary and mandibular perimeter reduced over time. However, mandibular crowding increased in the given time. In a study on 47 children, Sampson and Richards (18) studied the prediction of probable crowding in mandibular incisors and canines in mixed dentition period and concluded that the arch shape and mesiodistal size of incisors were important determinants of crowding. In their longitudinal study on 150 children, Sanin and Savara (7) investigated the factors affecting the alignment of mandibular anterior teeth. They concluded that labial position of central incisors, higher inclination of perma-

| Table 4. Association of Measured Variables with Different Statuses of Eruption Precedence of the First Permanent Teeth |
|---------------------------------------------------------------|-----------------|-----------------|-----------------|
| Eruption Precedence                                         | P Value         |
| Inter-molar width man                                        | > 0.05          |
| Inter-molar width max                                        | > 0.05          |
| Inter-canine width man                                       | 0.003           |
| Inter-canine width max                                       | > 0.05          |
| Arch perimeter man                                           | 0.006           |
| Arch perimeter max                                           | 0.022           |
| Arch depth man                                               | > 0.05          |
| Arch depth max                                               | > 0.05          |
| Overbite                                                     | > 0.05          |
| Overjet                                                      | 0.038           |

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nent molars in maxillary plane and small size of mandibu-
lar incisors in mesiodistal dimension reduced the extent of
crowding. They studied the children in two stages. First,
when the mandibular incisors and permanent first molars
had erupted, and when all permanent teeth anterior to
first molars were in occlusion and most subjects had sec-
ond molars. In the present study, we also studied the chil-
dren in two stages, but in our study the first stage was in
the late primary dentition period and the second stage was
when the first permanent tooth had been fully erupted.
In the current study, eruption of central incisors and per-
manent first molars was taken into account, while in the
study of Sanin and Savara (7), eruption of all incisors and
permanent first molars was considered important. They
also found that 89% of patients with dental crowding had
also crowding in permanent dentition in early mixed den-
tition, and crowding was treated in only 11% of them.

It can be concluded from the above studies that arch
perimeter, shape, size, alignment and inclination of in-
cisors and permanent molars are important variables in-
volved in mandibular anterior crowding. Some acquired
habits such as finger sucking make the teeth lingual and
cause mandibular anterior crowding. Thus, the impor-
tance of such attributes has to be explained to the parents,
and in the case of presence of such habits, relevant ther-
apies need to be implemented. In addition to the above-
mentioned points, dental eruption precedence is an im-
portant element involved in crowding

Eruption of mandibular central incisors, mandibular
first molars and maxillary first molars occurs in the age
range of 6 - 7 years (19). In a number of children, central
incisors erupt firstly, and in another group, molars erupt
first (20). Based on this difference in the time of erup-
tion, this hypothesis comes to mind that eruption prece-
dence of mandibular first molars or central incisors can
affect inter-molar and inter-canine width, arch perimeter,
arch depth, overjet and overbite during transition from
primary dentition period to permanent dentition period.
Eruption of maxillary central incisors occurs in the age
range of 7 - 8 years (19), which is about one year later than
the eruption of maxillary permanent molars. Therefore,
eruption of maxillary permanent first molars usually oc-
curs first. Absence of simultaneous eruption of maxillary
central incisors and permanent first molars diminishes
the importance of eruption precedence in maxilla com-
pared to mandible. Eruption precedence of permanent
first molars or mandibular central incisors is one of the fac-
tors that have rarely been investigated in other studies. In
fact, the relationship of this variable with other variables
of children’s dental system, which is in mixed dentition pe-
riod, has been almost disregarded.

In our study, there was a significant association be-
tween eruption precedence and inter-canine width. Inter-
canine width increased more in the group with eruption
of mandibular central incisors than the group with erup-
tion of first molars. Intercanine width increase between
the ages of 6 and 9 associated with the eruption of perma-
nent incisors observed in other studies too (2, 21). This can
be due to the larger mesiodistal size of permanent central
incisors rather than primary central incisors, which exerts
a force to the primary lateral incisors and primary canines
and increases the inter-canine width.

In the current study, the mandibular arch length
increased with simultaneous eruption of maxillary and
mandibular permanent first molars. The maxillary arch
perimeter had higher increase with eruption of maxillary
first molar and simultaneous eruption of maxillary and
mandibular first molars than with eruption of permanent
central incisors. This can be due to the eruption of max-
illary first molar buccodistally. However, further studies
are required to find a definitive reason for this increase.
Arsalan et al. showed that there was no significant differ-
ces in arch perimeter and arch depth during the transi-
tion from mixed to permanent dentition in all groups (22).
This difference could be attributed to the permanent den-
tition which was evaluated in Arsalan et al. while in this
study we evaluated early mixed dentition not the perma-
nent dentition.

As eruption precedence affects dental crowding, den-
tal crowding also affects tooth eruption. For instance,
Moshkelgosha et al. carried out a study on 72 children
aged 8 - 12 years and reported that eruption percentage of
mandibular first premolar was significantly higher than
that of canine in the children with dental crowding, while
this eruption difference was not significant in children
without dental crowding (23).

The arch dimensions change regularly during growth
and development, but this change is lower in adulthood
(24). In the present study, measurement of inter-canine
width, inter-molar width, arch perimeter and depth, over-
jet and overbite was done on dental casts in two stages, in-
cluding primary and mixed dentition periods.

Normando et al. showed that inter-canine-width, inter-
molar-width and arch length were higher in Assurini pop-
ulation than Arara and Xicrin-Kaiap populations (25). The
study of Ling and Wong on 358 children aged 12 years in
south China indicated that, except in incisor area, boys had
a higher arch width than girls, and these children had a
larger arch width than Caucasian children (26). The results
of the research by Zafarmand et al. on 3 - 5-year-old Filipino
children showed inter-canine width and inter-molar width
in girls and arch length in boys were significantly different
between various age groups (27).

Heikinheiro et al. reported maxillary arch perimeter

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during transition from mixed dentition (8 - 9 years) to permanent dentition (13 - 14 years) significantly increased in both genders, while it was reverse in the mandible. Heikinheimo et al. showed intercanine width increased both in girls and boys from 7 to 10 years old and intermolar width increased between 7 and 15 years of age. Overjet was also increased between 7 to 10 years old and overbite increase was observed between 7 and 12 years old (28). Further, in this study canine-molar distance and incisor-molar distance in all four segments in this transition period were decreased, but incisor-canine distance was increased (29). A similar study by Wermerson showed maxillary and mandibular arch perimeter reduced more than maxilla during transition from mixed dentition to permanent dentition (30). In a forty-year follow-up study on 22 patients starting from age 13, Massaro et al. reported that anterior crowding and clinical crown height of posterior teeth increased and mandibular inter canine width, length and arch perimeter significantly decreased. Moreover, maxillary and mandibular inter-molar width slightly increased, but this difference was not statistically significant (31).

In the present study, inter molar width increased more after eruption of first permanent tooth than primary dentition period. Further, mandibular inter-canine width, maxillary and mandibular arch perimeter and overbite increased.

Based on the above studies, it can be concluded that inter-canine width, maxillary and mandibular arch perimeter and overbite increase slightly in transition from primary dentition to mixed dentition period. In addition, mandibular arch perimeter reduces in transition from mixed to permanent dentition period. However, these values decrease in permanent dentition (from about the age of 13). As for these changes after orthodontic treatment, Lopez-Areal et al. reported that inter-canine width, intermolar width and overjet were almost the same after or- thodontic treatment (11).

So it seems that eruption precedence of permanent teeth could be considered among the factors which could influence the crowding in arches.

5.1. Conclusions

The eruption precedence had a significant impact on mandibular inter-canine width, maxillary arch perimeter, mandibular arch perimeter and overjet.

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Footnotes

Conflict of Interests: None.

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