The relationship of the occurrence between three-rooted deciduous mandibular second molars and three-rooted permanent mandibular first molars in children

Chia-ling Hsu a, Jou-en Huang b, Hui-ling Chen b, Ming-gene Tu c,d, Jeng-fen Liu a,e*

Abstract  Background/purpose: This study aimed to determine the correlation between the occurrence of three-rooted deciduous mandibular second molars and three-rooted permanent mandibular first molars in children.

Materials and methods: Orthopantograms (n = 977) obtained from August 2008 to December 2010 were retrospectively screened and examined. Among the 977 orthopantograms, those of 591 participants (314 boys and 277 girls; mean age, 8.7 years) with bilateral deciduous mandibular second molars and permanent mandibular first molars were studied. The gender predilection and prevalence of three-rooted mandibular molars were assessed, and the pattern of concurrence was investigated.

Results: The prevalence of three roots were 28.4% and 27.6% in the deciduous mandibular second molars and permanent mandibular first molars, respectively. Bilateral occurrence of three-rooted mandibular molars was almost 60% for both deciduous and permanent molars. There was a significantly greater prevalence of three-rooted mandibular molars on the right side of the mandible than that on the left side.

Conclusion: Deciduous and permanent molars show a similar prevalence of three roots. The presence of three-rooted deciduous mandibular second molar can strongly predict the possibility of three roots in permanent mandibular first molar.
Introduction

Knowledge of tooth and root canal anatomy is important in dental practice and for accurately identifying features of anthropologic significance. Deciduous mandibular second molars usually have two roots and three root canals, and the presence of accessory roots is rather uncommon.1,2 The prevalence of dental anomalies is lower in the deciduous dentition than that in the permanent dentition.3 The prevalence of accessory third roots in the permanent mandibular first molar variant with three roots typically occurs lingually. Such an additional root was first described by Carabelli4 and was termed as ‘radix entomolaris’.5 This supernumerary root is typically smaller than the distal root and is usually curved, requiring special consideration during endodontic treatments.6

The prevalence of accessory third roots in the permanent mandibular molars has been extensively investigated, which is not true for the prevalence of the deciduous mandibular molars. Liu reported that approximately 10% patients in a Taiwanese hospital had three-rooted deciduous mandibular second molars, detected by vertical biting radiographs.7 Recent Indian studies performed using intraoral periapical radiographs showed that 5.6–6.5% Indian children had three-rooted deciduous mandibular molars.8,9 In Taiwan, 21–27% of the surveyed patient populations had three-rooted permanent mandibular first molars.10,11 However limited information has been reported in the literature regarding the correlation between the occurrence of three-rooted deciduous mandibular second molars and three-rooted permanent mandibular first molars.

Thus, the purpose of this retrospective study was to determine the relationship between the occurrence of three-rooted deciduous mandibular second molars and three-rooted permanent mandibular first molars using orthopantograms of Taiwanese children.

Materials and methods

A total of 977 orthopantograms obtained from the Department of Pediatric Dentistry between August 2008 to December 2010 were retrospectively screened and analyzed. Ethical approval was obtained from the Institutional Review Board of Taichung Veterans General Hospital (CE18344A). The criteria for selection of participants were as follows: orthopantograms with good visual characteristics, clearly showing the deciduous mandibular second molars and permanent mandibular first molars of both sides, presences of bilateral deciduous mandibular second molars and permanent mandibular first molars, no radiolucency or furcation involvement associated with the analyzed teeth, deciduous mandibular second molars with resorption in less than one-fourth of the root area, permanent mandibular first molars with complete root formation in more than two-thirds of the root surface. To reduce radiographic misinterpretation, blurred radiographs were excluded.

Among the 977 the selected orthopantograms, those of 591 participants (314 boys and 277 girls) showing the presence of bilateral deciduous mandibular second molars and permanent mandibular first molars (1182 deciduous mandibular second molars, 1182 permanent mandibular first molars) were chosen for this investigation. Two calibrated pediatric dentists examined the orthopantograms. In this investigation, an extra root was defined as a clearly distinguishable independent extra root, evident as the crossing of translucent lines defining the pulp and periodontal ligament spaces, in accordance with the criteria described in previous studies (Fig. 1).7,10,12 Disagreements in the interpretation of radiographs were resolved by consensus between the two investigators. The kappa value was calculated to quantify the inter-examiner reliability. The overall prevalence, gender predilection, and prevalence of bilateral and unilateral right- or left-side three-rooted deciduous mandibular second molars and three-rooted permanent mandibular first molars were determined.

Statistically significant differences in gender and side were evaluated using the chi-square test with significance set at P < 0.05. The correlation between left-side and right-side occurrences of three-rooted molars were determined by the McNemar’s test. Odds ratios and their 95% confidence intervals were used to assess the statistical significance of correlations between the occurrence of three-rooted deciduous mandibular second molars and three-rooted permanent mandibular first molars. Analyses were performed using the SPSS 19.0 software (IBM Corp., Armonk, NY, USA).

Results

The kappa values for the diagnosis of three-rooted deciduous mandibular second molars and three-rooted permanent mandibular first molars were 0.89 and 0.85, indicating good inter-examiner reliability.

Detailed data on the prevalence of three-rooted mandibular molars based on tooth, gender, and side are shown in Tables 1–3. The mean age of the 591 participants was 8.7 years. A total of 93 boys (29.6%, 93/314) and 75 girls (27%, 75/277) had three-rooted deciduous mandibular second molars (Table 1). The overall prevalence of these teeth was 28.4% (168/591), with these teeth representing 22.4% (265/1182) of the total number of teeth. Eighty-eight boys (28.8%, 88/314) and 75 girls (27%, 75/277) had three-rooted permanent mandibular first molars. The overall prevalence of these teeth was 27.6% (163/591), with these
teeth comprising 22% (260/1182) of the total number of teeth (Table 1). The prevalence of three roots was higher in the deciduous mandibular second molars than that in the permanent mandibular first molars, but the difference was not statistically significant (P > 0.05). The chi-square test revealed that the prevalence of three roots in both types of teeth did not differ between genders (P > 0.05). The prevalence of three roots was higher on the right side than that on the left side for both types of teeth regardless of gender (P < 0.001, Table 2). The prevalences of bilateral three-rooted permanent mandibular first molars and three-rooted deciduous mandibular second molars among the three-rooted subjects were 59.5% (97/163) and 57.7% (97/168), respectively (Table 3).

The probability that a third root would be present in a permanent mandibular molar posterior to a deciduous mandibular molar with an extra root was 75.7% on the right side and 65.5% on the left side. The presence of three-rooted deciduous mandibular second molars was significantly correlated with the presence of three-rooted permanent mandibular first molars on the right (odds ratio = 30.2; 95% confidence interval 18.5—49.3; p < 0.001) and left sides (odds ratio = 28.3; 95% confidence interval 16.6—48.4; p < 0.001, Table 4).

**Discussion**

When present, the additional root in a mandibular molar is usually located distolingually. Tratman suggested that the additional root is not simply a division of the distal root, but is a true extra root with a separate orifice and apex. In the permanent mandibular first molars, an additional root is common in races of Mongoloid origin. In our study, the prevalence of three-rooted permanent mandibular first molars was investigated using orthopantograms. We found that 27.6% of all participants and 22.0% of all examined teeth showed the presence of extra roots. Previous studies

| Table 1 | Prevalence of three-rooted mandibular molars. |
|---------|---------------------------------------------|
|         | Deciduous mandibular second molars | Permanent mandibular first molars |
|         | Total  | Teeth (number (%) | Teeth (number (%)) | Total  | Teeth (number (%) | Teeth (number (%)) |
| Male    | 314    | 93 (29.6) | 628 | 147 (23.4) | 314    | 88 (28.0) | 628 | 139 (22.1) |
| Female  | 277    | 75 (27.0) | 554 | 118 (21.3) | 277    | 75 (27.0) | 554 | 101 (18.2) |
| Total   | 591    | 168 (28.4) | 1182 | 265 (22.4) | 591    | 163 (27.6) | 1182 | 260 (22.0) |

| Table 2 | Distribution of three-rooted mandibular molars on the right and left sides. |
|---------|---------------------------------------------|
|         | Deciduous mandibular second molars | Permanent mandibular first molars |
|         | Total | Right no. (%) | Left no. (%) | P value | Total | Right no. (%) | Left no. (%) | P value |
| Male    | 314   | 82 (26.1) | 65 (20.7)* | p = 0.009 | 314   | 82 (26.1) | 57 (18.2)* | p < 0.001 |
| Female  | 277   | 70 (25.3) | 48 (17.3)* | p < 0.001 | 277   | 74 (26.7) | 47 (17.0)* | p < 0.001 |
| Total   | 591   | 152 (25.7) | 113 (19.1)* | p < 0.001 | 591   | 156 (26.4) | 104 (17.6)* | p < 0.001 |

McNemar’s test.  
*p < 0.05.
have reported a prevalence of 43.6% in Aleutian,\cite{12} 8.0%—
25.8% in Chinese,\cite{10,13,14} 10.9%—22.7% in Japanese,\cite{10,15} and
33.1% in Korean\cite{16} populations. Jorgensen\cite{17} reported seven cases (0.67%) of additional
roots in 1041 deciduous mandibular second molars extracted
from participants of a Danish population. Liu et al.\cite{7} evaluated
the prevalence of three-rooted primary deciduous mandibular
second molars retrospectively among patients in Taiwan and
found an overall prevalence of 10%. The study also reported a
bilateral prevalence (symmetrical distribution) of 28% for
three-rooted deciduous mandibular second molars.\cite{7} Yang
et al.\cite{18} determined the prevalence of three-rooted deciduous
mandibular primary second molars in Chinese children as
27.52%, using cone-beam computed tomography (CBCT). In
our study, we investigated the prevalence of three-rooted
deciduous mandibular second molars in a Taiwanese popula-
tion and found that 28.4% (168/591) of the examined patients
show the presence of extra roots. The value is consistent with
the result reported in the aforementioned study by Yang
et al.,\cite{18} but higher than that reported in a previous study.\cite{7}
However the previous study used bitewing radiographs for
analysis. We used orthopantograms in this study, and this
could be the reason for different results.

Table 3  Bilateral prevalence of three-rooted mandibular molars.

|                        | Unilateral | Bilateral |
|------------------------|------------|-----------|
|                        | Participants | Right no. (%) | Left no. (%) | P value | no. (%) | Total no. (%) |
| Deciduous mandibular second molars | Male | 314 | 28 (8.9) | 11 (3.5) | p = 0.008* | 54 (17.2) | 93 (29.6) |
|                        | Female | 277 | 27 (9.7) | 5 (1.8) | p < 0.001* | 43 (15.5) | 75 (27.0) |
|                        | Total   | 591 | 55 (9.3) | 16 (2.7) | p < 0.001* | 97 (16.4) | 168 (28.4) |
| Permanent mandibular first molars | Male | 314 | 31 (9.9) | 6 (1.9) | p < 0.001* | 51 (16.2) | 88 (28.0) |
|                        | Female | 277 | 28 (10.1) | 1 (0.4) | p < 0.001* | 46 (16.6) | 75 (27.0) |
|                        | Total   | 591 | 59 (10.0) | 7 (1.2) | p < 0.001* | 97 (16.4) | 163 (27.6) |

Chi-square test.
*p < 0.05.

Mayhall\cite{15} suggested that if a deciduous mandibular
second molar has an additional root, there is a high prob-
ability that the permanent mandibular first molar will also
have one. Song et al.\cite{19} determined the incidence of addi-
tional roots in deciduous mandibular and permanent
mandibular molars and analyzed their relationship. Addi-
tional roots were present in 33.1%, 27.8%, and 9.7% of the
permanent mandibular first molars, and deciduous
mandibular second molars, first molars, respectively. They
found that when an additional root was present in a de-
ciduous molar, the probability of the tooth posterior to
deciduous molar showing the presence of an additional root
was greater than 94.3%. The simultaneous occurrence of
additional distolingual roots was significant in permanent
mandibular first molars with either deciduous mandibular
second molars or permanent mandibular second molars
(odds ratio = 36.0 and 5.3).\cite{16} We also found a high prob-
ability of simultaneous occurrence of extra third roots in
deciduous mandibular second molars and permanent
mandibular first molars. When an extra third root was
present in the deciduous mandibular second molar, there
was a greater likelihood of the permanent mandibular first
molar to simultaneously present with an extra third root

Table 4  Correlation between the occurrence of three-rooted deciduous mandibular second molars and permanent mandibular
first molars.

| K/T | 19/30 | Right side | Probability | Odds ratio 95% CI | Left side | Probability | Odds ratio 95% CI |
|-----|-------|------------|-------------|-------------------|-----------|-------------|-------------------|
| O 0 | 115 (19.5) | 75.7 | 30.2* (18.5—49.3) p < 0.001 | 74 (12.5) | 65.5 | 28.3* (16.6—48.4) p < 0.001 |
| O X | 37 (6.3) | 24.3 | | 39 (6.6) | 34.5 | |
| X 0 | 41 (6.9) | 9.3 | | 30 (5.1) | 6.3 | |
| X X | 398 (67.3) | 90.7 | | 448 (75.8) | 93.7 | |

K/T: Deciduous mandibular left/right second molar.
19/30: Permanent mandibular left/right first molar.
O: mandibular molar with an additional root.
X: mandibular molar without an additional root.
Odds ratio = (OO x XX)/(OX x XO).
CI: confidence interval.
*p < 0.05.
(odds ratio = 30.2 on the right side; 28.3 on the left side, \( p < 0.001 \)).

Limited data have been reported in the literature regarding the exact etiological mechanisms underlying the development of an extra root. Dahlberg\(^\text{20}\) and Turner\(^\text{12}\) reported that the deciduous mandibular second molars and permanent mandibular first molars belong to the same molar field because of their same time of development and similar crown morphology. Turner also described the permanent mandibular first molar as the primary site for field-affecting genes.\(^\text{12}\) The similarity in the development of the permanent mandibular first molar and deciduous mandibular second molar might explain the simultaneous occurrence of extra third roots.

Song et al.\(^\text{19}\) found a significant gender predilection in males over females for the presence of extra roots in the mandibular molars. However we did not find any gender predilection for the occurrence of three-rooted deciduous and permanent mandibular molars (\( p > 0.05 \)), which is in agreement with the results reported in Taiwanese individuals.\(^\text{7,10,21}\)

According to the results of our study, extra third roots in the deciduous mandibular second molars and permanent mandibular first molars occurred more frequently on the right side than on the left side (\( p < 0.001 \)). In many previous studies, three-rooted permanent mandibular first molars were showed to have a predilection toward the right side,\(^\text{10,16,19,21–23}\) whereas a left-side predilection has been reported less frequently.

Studies of permanent teeth have shown high bilateral occurrences of extra roots in mandibular molars. In our study, the incidence of bilateral three-rooted permanent mandibular first molars was 59.5% (97/163). This result is similar to those of studies conducted with Asian populations, i.e., 54.6%–67%,\(^\text{10,16,19,21–23}\) and the incidence was higher than that reported by Garg et al.,\(^\text{23}\) who investigated the prevalence in Asian Indians (37.14%) using periapical radiographs. In our study, the incidence of bilateral three-rooted deciduous mandibular second molars was 57.7% (97/168). Song et al.\(^\text{16}\) determined the prevalence of bilateral three-rooted deciduous mandibular second molars using CBCT as 81.8% (9/11) in Korean children. The variation in the incidence of three-rooted mandibular molars can be attributed to multiple factors, such as the sample size, study design, method of analysis, and populations studied.

Two principle methods have been used to evaluate the prevalence of extra third roots in previous studies. Radiography is a noninvasive and practical method, which allows inter-study comparisons pertaining to gender and bilateral occurrence. The morphology of three-rooted deciduous and permanent molars can more accurately determined in extracted teeth. However it is an invasive method. According to Walker and Quackenbush,\(^\text{27}\) the presence of a third root is clearly evident in approximately 90% cases radiographically. In our study, we used orthopantomograms, rather than extracted teeth, for analyzing larger number of teeth. However, more accurate methods for determining the prevalence of three-rooted mandibular molars are extraction and CT. Recently, Tu et al.,\(^\text{10}\) Song et al.,\(^\text{16}\) and Garg et al.,\(^\text{23}\) investigated the incidence of extra roots in mandibular deciduous and permanent mandibular molars using CT. Conventional radiographs only provide a two-dimensional view of the teeth, whereas spiral CT can show detailed three-dimensional images, which can be useful for endodontic applications and morphologic analyses. In contrast to traditional CT, CBCT is characterized by the rapid acquisition of a volume image from a single, low radiation-dose scan of the patient and has a higher resolution.\(^\text{22,28}\) The use of CBCT facilitated detailed and accurate assessment of such teeth without extracting the teeth, and provides images that are more reliable than those obtained by other methods used for determining the prevalence of dental anomalies. However, the routine application of CBCT in children is not recommended due to the additional cost and radiation exposure.

Dentists should be aware of the prevalence of additional roots in deciduous and permanent teeth among Taiwanese children before starting endodontic treatment. This study provides reliable data pertaining to the prevalence of extra roots and the relationship between the occurrence of three-rooted deciduous mandibular second molars and three-rooted permanent mandibular first molars. In conclusion, approximately one fourth of the Taiwanese population exhibits three-rooted deciduous mandibular second molars or permanent mandibular first molars, and approximately 60% exhibit bilateral occurrence of third roots in their deciduous mandibular second molars or permanent mandibular first molars. The probability of the simultaneous occurrence of extra third roots in permanent mandibular first molars and deciduous mandibular second molars is significantly high. The presence of a three-rooted deciduous mandibular second molar is strongly predictive of the presence of a three-rooted permanent mandibular first molar.

Declaration of competing interest

The authors have no conflicts of interest relevant to this article.

Acknowledgment

This study was supported by the Department of Pediatric Dentistry, Taichung Veterans General Hospital, Taichung, Taiwan.

References

1. Mann RW, Dahlberg AA, Stewart TD. Anomalous morphologic formation of deciduous and permanent teeth in a 5-year-old 15th century child: a variant of the Ekman-Westborg-Julin syndrome. Oral Surg Oral Med Oral Pathol 1990;70:90–4.
2. Winkler MP, Ahmad R. Multirooted anomalies in the primary dentition of Native Americans. J Am Dent Assoc 1997;128:1009–11.
3. Menczer LF. Anomalies of the primary dentition. J Dent Child 1955;22:57–62.
4. Carabelli G. Systematisches handbuch der Zahnheilkunde, 2nd ed. Vienna: Baumuller and Seidel, 1844:114.
5. Boik L. Bemerkungen über Wurzelvariationen am menschlichen unteren Molaren. Zeiting fur Morphologie Anthropologie 1915;17:605–10.
Three roots in mandibular molars

6. Vertucci FJ, Haddix JE, Britto LR. Tooth morphology and access cavity preparation. In: Cohen S, Hargreaves KM, eds. Pathways of the pulp, 9th ed. St Louis: CV Mosby, 2006:149–232.

7. Liu JF, Dai PW, Chen SY, Huang HL, Hsu JT, Chen WL. Prevalence of 3-rooted primary mandibular second molars among Chinese patients. Pediatr Dent 2010;32:123–6.

8. Srivathsa SH. Prevalence of three rooted deciduous mandibular molars in Indian children. Int J Dent Sci Res 2015;2:14–6.

9. Nagaveni NB, Poornima P, Valsan A, Mathew MG. Prevalence of three-rooted primary mandibular second molars in Karnataka (South Indian) population. Int J Pedod Rehabil 2018;3:33–5.

10. Tu MG, Tsai CC, Jou MJ, et al. Prevalence of three-rooted mandibular first molars among Taiwanese individuals. J Endod 2007;33:1163–6.

11. Huang RY, Lin CD, Lee MS, et al. Mandibular distolingual root: a consideration in periodontal therapy. J Periodontol 2007;78:1485–90.

12. Turner II CG. Three-rooted mandibular first permanent molars and the question of American Indian origins. Am J Phys Anthropol 1971;34:229–41.

13. Tratman EK. Three-rooted lower molars in man and their racial distribution. Br Dent J 1939;64:264–74.

14. Wang Y, Zheng QH, Zhou XD, et al. Evaluation of the root and canal morphology of mandibular first permanent molars in a western Chinese population by cone-beam computed tomography. J Endod 2010;36:1786–9.

15. Mayhall JT. Three-rooted deciduous mandibular second molars. J Can Dent Assoc 1981;47:319–21.

16. Song JS, Choi HJ, Jung JY, Jung HS, Kim SO. The prevalence and morphologic classification of distolingual roots in the mandibular molars in a Korean population. J Endod 2010;36:653–7.

17. Jorgensen KD. The deciduous dentition: a descriptive and comparative anatomical study. Acta Odontol Scand 1956;14:201–2.

18. Yang C, Yang R, Zou J. Investigation of root and canal morphology of human primary mandibular second molar by cone-beam CT. Zhonghua Kou Qiang Yi Xue Za Zhi 2013;48:325–9.

19. Song JS, Kim SO, Choi BJ, et al. Incidence and relationship of an additional root in the mandibular first permanent molar and primary molars. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2009;107:e56–60.

20. Dahlberg AA. The changing dentition of man. J Am Dent Assoc 1945;32:676–90.

21. Tu MG, Huang HL, Hsue SS, et al. Detection of permanent three-rooted mandibular first molars by cone-beam computed tomography imaging in Taiwanese individuals. J Endod 2009;35:503–7.

22. Jayasinghe RD, Li TKL. Three-rooted first permanent mandibular molars in a Hong Kong Chinese population: a computed tomographic study. Hong Kong Dent J 2007;4:90–3.

23. Garg AK, Tewari RK, Agrawal N. Prevalence of three-rooted mandibular first molars among Indians using SCT. Int J Dent 2013;2013:183869.

24. Loh HS. Incidence and features of three-rooted permanent mandibular molars. Aust Dent J 1990;35:434–7.

25. Yew SC, Chan K. A retrospective study of endodontically treated mandibular first molars in a Chinese population. J Endod 1993;19:471–3.

26. Garg AK, Tewari RK, Kumar A, Hashmi SH, Agrawal N, Mishra SK. Prevalence of three-rooted mandibular permanent first molars among the Indian population. J Endod 2010;36:1302–6.

27. Walker RT, Quackenbush LE. Three-rooted lower first permanent molars in Hong Kong Chinese. Br Dent J 1985;159:298–9.

28. Patel S, Horner K. The use of cone beam computed tomography in endodontics. Int Endod J 2009;42:755–6.