Mandibular second molar impaction. Part I: Genetic traits and characteristics

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Introduction: Detection of mandibular second molar (MM2) impaction is imperative for orthodontic diagnosis and treatment. In this study, we examined a possible genetic trait in MM2 impaction in 2 populations and defined distinctive characteristics. Methods: Initial panoramic radiographs of patients of Israeli (n = 3500) and Chinese-American (n = 3000) origin, aged 11 to 15 years, were examined. Twelve distinctive characteristics were compared between the unilateral impacted and the nonimpacted sides. Results: A total of 120 subjects with MM2 impaction were found (1.8%). The Chinese-American population had a higher prevalence (n = 71, 2.3%) of MM2 impaction compared with the Israeli population (n = 49, 1.4%; \( P = 0.004 \)). For the subjects with MM2 impaction, the Israelis had significantly (\( P = 0.039 \)) fewer bilateral impactions (27%) than did the Chinese-Americans (45%). Mesially inclined impacted MM2s were more common (88% and 89%) in the Israeli and Chinese-American populations, respectively. The unilateral impacted side demonstrated reductions in the distance between the mandibular first molar and the ramus (\( P < 0.001 \)), the length of the mesial root of the MM2 (\( P < 0.001 \)), and the height between the MM2 and the mandibular third molar, and increases in the angulations of the MM2 (\( P < 0.001 \)) and the mandibular third molar (\( P < 0.003 \)). Conclusions: An autosomal genetic trait is present in MM2 impaction with greater penetrance in the Chinese-American population. Within developmental impediments, the deficient mesial root length of the MM2 is the primary impaction factor. (Am J Orthod Dentofacial Orthop 2011;140:32-7)
During a 10-year study period was reported by Evans. A possible explanation for this phenomenon is that the MM2 requires the guidance of the roots of the first molar (MM1) (eg, with a lip bumper). Similarly, it could well be that the MM2 requires the guidance of the roots of the MM1 crown. The null hypotheses of this study were that the MM2 requires the guidance of the roots of the MM1 during its eruption. Moreover, unlike reports suggesting a close association between arch-length deficiency and MM2 impaction, excess space between the developing MM2 and MM1 might allow a more mesial inclination of the MM2, resulting in impaction under the distal bulge or the height of the contour of the MM1 crown. The MM2 might occasionally upright itself spontaneously, if the third molar (MM3) bud is not developing on top of, or pressing against, the erupting MM2. In contrast, the MM2 might further incline mesially, resulting in oblique or horizontal impaction.

A 3-fold increase in the prevalence of MM2 impaction during a 10-year study period was reported by Evans. She suggested that, in extraction patients, change in the previous extraction pattern of MM1 (larger teeth) in Bristol, England, to the extraction pattern of the first premolars (smaller teeth) resulted in a shortage of space for the MM2 and probably contributed to this impaction increase. Compared with nonextraction treatment, extraction of a premolar in each buccal segment and closure of the extraction spaces might allow the eruption of the otherwise unerupted MM2s. However, if an MM2 is strongly mesially angulated, it might not erupt even if space is provided. Interestingly, a close association was found between unilateral impaction of MM2 and a mandibular midline shift toward the impacted tooth. The suggested explanation was an asymmetric space deficiency for the erupting MM2 by the side affected by the shift.

Early detection of the arrested eruption of an MM2 is imperative, because corrective measures might eliminate its potential impaction and reduce the need for complicated orthodontic treatment.

The objectives of this study were to evaluate genetic traits by comparing the prevalence of MM2 impaction in Israeli and Chinese-American populations, and to define distinctive linear and angular characteristics of the impacted side by comparing measurements of the impacted side with those of the nonimpacted side.

The null hypotheses of this study were that the prevalence rates of MM2 impactions in Israelis and Chinese-Americans are similar, and there is no difference in dentoskeletal parameters between the impacted and the nonimpacted sides.

**MATERIAL AND METHODS**

For the first objective, initial panoramic radiographs were screened from 3000 consecutively treated Israeli patients from the Department of Orthodontics at Tel Aviv University as well as 500 consecutively treated Israeli patients from a private orthodontic practice.
(Y.S., Jerusalem, Israel), and 3000 consecutively treated patients of Chinese-American origin from a private orthodontic practice (Y.H.L., New York). All patients were aged 11 to 15 years (mean ages, 12.48 and 13.13 years for Israelis and Chinese-Americans, respectively). The total group’s mean age was 12.8 years ($P = 0.21$). There was no significant difference in the patients’ ages between the 2 groups. The study was approved by the Helsinki committee of Tel Aviv University.

For the second objective, 50 subjects with unilateral mesial impaction of MM2 were selected, 36 from the initial pool at Tel Aviv University and 14 from private practices of the faculty members.

The panoramic radiographs were scanned into the computer with 300-dpi resolution by using a scanner (PowerLook-1000, UMAX, Dallas, Tex). The digitized images were measured in pixels by using the Java image processing program (Image-J 1.34s, National Institutes of Health, Bethesda, Md). Only radiographs with similar right and left mesiodistal crown sizes of the MM1s were selected for the study. Since enlargement can differ between panoramic radiographs, comparisons were made between contralateral paired measurements in the same patient.15,16 All measurements were taken by the same examiner (T.F.) twice, and the average was calculated. The pixels were then converted to millimeters according to a calculated calibration where 1 mm = 7.874 pixels. Thus, the measurements in this study represent the actual sizes in millimeters as viewed on the panoramic radiographs.

MM2 impaction was defined according to the following criteria: (1) full eruption of the MM2 was observed on 1 side, but the contralateral MM2 had not emerged.
even though more than three quarters of 1 root was formed; and (2) the mesial cusps of the impacted MM2 were angulated and often locked in tight contact with the distal wall undercut of the MM1.

Table I and Figure 1 depict the 12 measurements made on the impacted and nonimpacted sides in each panoramic radiograph.

The statistical analysis included the Pearson chi-square test, used to compare the prevalence of MM2 impaction in the Israeli and Chinese-American populations (first objective). A paired t test was used to compare the linear and angular measurements of the impacted and the nonimpacted sides at a significance level of 0.05.

RESULTS

A total of 120 subjects with MM2 impaction were found (1.8%) of whom 49 (1.4%) were Israelis and 71 (2.3%) were Chinese-Americans (Table II).

Five parameters were compared: (1) prevalence of impaction, (2) unilateral vs bilateral impaction, (3) mesial vs distal inclination, (4) sex of the subjects with impactions, and (5) sidedness of the impactions (prevalence comparisons of left vs right impactions).

Of these, 2 parameters were significant (prevalence and unilateral vs bilateral impaction), 1 parameter was nearly significant at the stated level (right-left symmetry), and 2 were nonsignificant (mesial vs distal inclination, and sex) (Table II).

The comparison of 13 parameters between the impacted and nonimpacted sides of the 50 subjects with unilateral MM2 impaction showed significant differences in 7 of the 13 measured parameters (Table III). These included the distance between the MM1 and the anterior rim of the ramus ($P < 0.001$), the height between the MM2 and the MM3 ($P < 0.001$), the distance between the MM1 and the posterior rim of the ramus ($P = 0.006$), the length of the mesial root of the MM2 ($P < 0.001$), the length difference between the mesial and distal roots of the MM2 ($P < 0.001$), the angulation of the MM2 ($P < 0.001$), and the angulation of the MM3 ($P < 0.003$).

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Table II. Comparison of the 5 parameters between Israelis and Chinese-Americans

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Israel</th>
<th>Percentage</th>
<th>China</th>
<th>Percentage</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Prevalence</td>
<td>49</td>
<td>1.4%</td>
<td>71</td>
<td>2.3%</td>
<td>0.004*</td>
</tr>
<tr>
<td>2. Unilateral impaction</td>
<td>36</td>
<td>73%</td>
<td>39</td>
<td>55%</td>
<td>0.039*</td>
</tr>
<tr>
<td>3. Bilateral impaction</td>
<td>13</td>
<td>27%</td>
<td>32</td>
<td>45%</td>
<td></td>
</tr>
<tr>
<td>4. Mesial impaction</td>
<td>43</td>
<td>88%</td>
<td>63</td>
<td>89%</td>
<td>0.964</td>
</tr>
<tr>
<td>5. Vertical impaction</td>
<td>4</td>
<td>8%</td>
<td>6</td>
<td>8%</td>
<td></td>
</tr>
</tbody>
</table>

*Significance at 0.05 level.

Table III. Differences between the impacted and nonimpacted sides in the study groups

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Impacted (mean ± SD)</th>
<th>Nonimpacted (mean ± SD)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>a MM1 width (mm)</td>
<td>15.35 ± 1.9</td>
<td>15.43 ± 2.11</td>
<td>0.691</td>
</tr>
<tr>
<td>b MM2 width (mm)</td>
<td>14.72 ± 1.81</td>
<td>15.03 ± 2.33</td>
<td>0.117</td>
</tr>
<tr>
<td>c MM1-ramus ant (mm)</td>
<td>13.04 ± 2.7</td>
<td>18.28 ± 3.86</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>d Ramus width (mm)</td>
<td>36.02 ± 5.59</td>
<td>35.36 ± 5.55</td>
<td>0.234</td>
</tr>
<tr>
<td>e Ramus height (mm)</td>
<td>55.62 ± 6.85</td>
<td>55.5 ± 7.02</td>
<td>0.896</td>
</tr>
<tr>
<td>f Mand height (mm)</td>
<td>29.09 ± 4.65</td>
<td>29.06 ± 4.46</td>
<td>0.945</td>
</tr>
<tr>
<td>g MM2-MM3 (mm)</td>
<td>1.17 ± 4.14</td>
<td>3.87 ± 2.54</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>h MM1-ramus post (mm)</td>
<td>22.5 ± 5</td>
<td>24.04 ± 4.59</td>
<td>0.006*</td>
</tr>
<tr>
<td>i MM2 mesial root (mm)</td>
<td>21.22 ± 3.25</td>
<td>23.01 ± 3.62</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>j MM2 distal root (mm)</td>
<td>22.05 ± 3.45</td>
<td>21.65 ± 3.48</td>
<td>0.277</td>
</tr>
<tr>
<td>k MM2 roots diff (mm)</td>
<td>0.82 ± 0.89</td>
<td>1.35 ± 0.9</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>l-MM3-angulation (°)</td>
<td>134.66 ± 12.07</td>
<td>101.54 ± 7.8</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>m-MM3-angulation (°)</td>
<td>142.39 ± 11.14</td>
<td>134.46 ± 13.51</td>
<td>&lt;0.003*</td>
</tr>
</tbody>
</table>

*Significance at 0.05 level.
DISCUSSION

The prevalence of MM2 impaction found in the Israeli population (1.4%) was more than 4 times greater than that previously reported in the literature.5,7 The prevalence in the Chinese-American population (2.3%) was almost 2-fold larger than that in the Israeli population \(P = 0.004\) (Table II) but similar to a Swedish population (2.3%).17 These findings reject our first hypothesis that the prevalence of MM2 impaction in Israelis and Chinese-Americans is similar and suggests a genetic trait in this aberration. The latter finding is corroborated by a 2 to 3 times greater frequency of impacted MM3s in the Singapore Chinese than that reported in people of white stock.18

A genetic penetrance of MM2 impaction related to the severity of the aberration can be inferred from the ratio of bilateral to unilateral impaction, which was high in the Chinese-Americans (45:55) and low in the Israelis (27:73). That is, the population with a greater prevalence also demonstrated increased severity of the aberration (ie, more bilateral impactions). The lack of a prevailing sex in the populations (female to male ratio: 53:47 and 58:42 for the Israelis and Chinese-Americans, respectively) suggests the possibility of autosomal and not sex chromosome \(x\) or \(y\) inheritance. However, the direction of impaction (mesial, vertical, distal) was similar for both Israeli (88, 8, 4) and Chinese-American (89, 8, 3) populations \(P = 0.964\) (Table II). Clearly, mesial impactions consistently dominated \(P < 0.001\). This finding most likely suggests that for both populations the prerequisite condition for MM2 impaction is a developmental impediment, producing mesial crown tilt during the tooth’s preeruptive migration (see objective 2).

The fact that this aberration can appear as a unilateral form suggests right-left asymmetry. However, in contrast to those with cleft lip and palate19 and peg-shaped maxillary lateral incisors,20 where the asymmetry is predominantly on the left side (ie, 70%), MM2 asymmetry appears not to have a preferred or a dominant side.

All the mesially impacted MM2s had significant differences between the impacted and the nonimpacted sides. Differences were found in the distance of the MM1 to both the anterior and posterior rims of the ramus, the height between the MM2s and the MM3s, the angulations of the MM2s and MM3s, and the different lengths between the mesial and distal roots of the MM2 (Table III). These findings reject our second hypothesis of no differences in dentoskeletal parameters between impacted and nonimpacted sides.

The distance between MM1 and the ramus—ie, the available space for the MM2—was consistently smaller on the impacted side. In a previous study, a close association was found between unilateral impaction of MM2 and mandibular midline shift toward the impacted tooth, resulting in arch-length deficiency on that side.14 This factor (mandibular midline deviation) could not be verified in our study.

The height differences between the MM2s and MM3s were statistically smaller on the impacted side. We expected to find an increase in this parameter on the impacted side, reportedly because of the superior position of the MM3 (MM3s often “ride over” the MM2) and the inferior position of the impacted MM2. The decrease in the distance can be explained by the more superior position of the distal cusp of the impacted MM2 because of the mesial tilt, meaning that this played a major role in dictating this distance and generating the aberration.

The most interesting and somewhat surprising finding was the significant differences in lengths between the distal and mesial roots of the impacted MM2s. The developing mesial root was significantly \(P < 0.001\) shorter than the developing distal root (Fig 2, Table III). This was contrary to the normally erupting, nonimpacted MM2, where the developing mesial root was somewhat longer than the developing distal root \(P < 0.001\). The developmental impediment of the mesial root could explain the forward rotation and mesial inclination of the MM2 crown, resulting in impaction. Root development is stated to be regulated by the growth hormone before dentinogenesis, as well as during appositional growth of the dentin.21 Most likely, the mechanism is followed via growth hormone receptors in the Hertwig’s epithelial root sheath.

A theory of differential asymmetrical root development was suggested by Kokich.22 Root asymmetry can be caused by either increased length of the distal root
or decreased length of the mesial root. Our findings showed significantly shorter mesial roots in the mesially angulated impacted MM2s. Moreover, on the contralateral nonimpacted side, the roots were almost equal in length, and even the mesial root was slightly longer. Interestingly, the few subjects with distally impacted MM2s had longer mesial roots, probably causing counterclockwise rotation and distal angulation.

The question, under what conditions is the development of 1 root constrained, has not yet been answered. However, recently, a restriction in Hertwig’s epithelial root sheath elongation was demonstrated when bone morphogenetic protein 4 was administrated directly into the pulp cavity.  

CONCLUSIONS

MM2 impaction demonstrates a moderate genetic trait. This was inferred by comparing panoramic radiographs of subjects from Israeli and Chinese-American populations.

- The prevalence of MM2 impaction was almost 2-fold greater in the Chinese-Americans (2.3%) than in the Israelis (1.4%) \( P = 0.004 \).
- A genetic penetrance of MM2 impaction is related to the severity of the aberration. The ratio of bilateral to unilateral MM2 impaction was higher in the Chinese-Americans (45:55) than in the Israelis (27:73).
- MM2 impaction appears to be an autosomal trait, rather than inherited via the sex chromosomes; ie, there is no prevailing sex.
- Right-left asymmetry is present (unilateral impaction), but with no side preference.

The side with unilateral impacted MM2s in comparison to the nonimpacted side was characterized by the following.

- Shorter horizontal distance between MM1 and the anteroposterior rim of the ramus.
- Shorter vertical distance between MM2 and MM3.
- Greater mesial inclination of the impacted MM2 and MM3.
- Undersized length of the mesial root of the impacted MM2.
- Greater difference in length between the distal and mesial roots of the impacted MM2.

Most likely, the primary causative factor in MM2 impaction is the arrested development of its mesial root, and the secondary factor might be the lack of space between the MM1 and the ascending ramus.

REFERENCES