The eruption of third molars (M3s) is restricted by adjacent tissue and limited space, and M3s often indeed fail to fully erupt1,2. Their anatomical features frequently lead to food impaction and plaque accumulation in M3 regions3. Insufficient plaque control makes M3s and their neighbours, adjacent second molars (A-M2s), vulnerable to periodontal diseases4. Studies have found laboratory evidence of increased levels of periodontal pathogens in M3 regions, even with few clinical symptoms of periodontal diseases5,6. Periodontal pathogens in M3 regions develop and the periodontal status of A-M2s is affected by age7. As early as the 1960s, Ash et

Relationship between Presence of Third Molars and Prevalence of Periodontal Pathology of Adjacent Second Molars: a Systematic Review and Meta-analysis

Yang YANG1#, Yi TIAN1#, Li Juan SUN1, Hong Lei QU1, Fa Ming CHEN1

Objective: To estimate the mean prevalence of periodontal pathology of adjacent second molars (A-M2s) to third molars (M3s) and identify related confounding factors.

Methods: Studies published before August 2020 were systematically searched in the Cochrane Library, EMBASE and MEDLINE databases. We included cross-sectional studies that evaluated the periodontal pathology of A-M2s based on clinical or radiographic examinations at the molar level. Studies employing similar periodontal parameters were pooled. Clinical attachment loss ≥ 3 mm, alveolar bone loss ≥ 3 mm or ≥ 20% root length were defined as early periodontal defects, and at least one site with probing depth ≥ 5 mm was considered as deep periodontal pockets around A-M2s in the data synthesis.

Results: Nine studies (14,749 M3s) were ultimately included in the meta-analysis. On average, 19% of A-M2s showed distal early periodontal defects with the presence of M3s (95% confidence interval [95% CI] 9%–35%). Subgroup analyses suggested the prevalence was 32% (95% CI 16%–54%) in the mandible, and the prevalence was higher with nonimpacted M3s (25%, 95% CI 12%–47%) than with impacted M3s (19%, 95% CI 10%–35%). Additionally, the pooled prevalence for deep periodontal pockets around A-M2s was 52% (95% CI 39%–64%). Subgroup analyses suggested the prevalence was higher in the mandible (62%, 95% CI 45%–76%) than in the maxilla (43%, 95% CI 31%–56%), and for nonimpacted M3s the prevalence reached 50% (95% CI 36%–64%).

Conclusion: The presence of M3s, especially mandibular and nonimpacted M3s, negatively affects the periodontal status of A-M2s.

Key words: meta-analysis, periodontal pathology, prevalence, second molars, third molars


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The eruption of third molars (M3s) is restricted by adjacent tissue and limited space, and M3s often indeed fail to fully erupt1,2. Their anatomical features frequently lead to food impaction and plaque accumulation in M3 regions3. Insufficient plaque control makes M3s and their neighbours, adjacent second molars (A-M2s), vulnerable to periodontal diseases4. Studies have found laboratory evidence of increased levels of periodontal pathogens in M3 regions, even with few clinical symptoms of periodontal diseases5,6. Periodontal pathogens in M3 regions develop and the periodontal status of A-M2s is affected by age7. As early as the 1960s, Ash et
reported the periodontal risks related to M3s. Since then, there have been a number of studies examining the relationship between the presence of M3s and the periodontal pathology of A-M2s. Prevalence is one of the most important pieces of data describing the epidemiological characteristics of the periodontal pathology of A-M2s; however, estimates of the prevalence of periodontal pathology of A-M2s at the molar level vary significantly among studies, ranging from 3.1% to 64.5%. Diverse periodontal parameters, including probing depth (PD), alveolar bone loss (ABL) and clinical attachment loss (CAL), accompanied by different examined sites (single or multiple sites around A-M2s), have been employed to evaluate the periodontal status of A-M2s, which may partly account for the statistically significant variance in results. Nevertheless, different characteristics of M3s and patients may also contribute to the high degree of heterogeneity in prevalence. Impacted M3s (I-M3s) have been reported to be associated with negative periodontal influences on A-M2s. Many studies have compared prevalence among impaction types, but diverse results have been recorded for various I-M3 classifications. In addition, studies on periodontal risks associated with nonimpacted M3s (N-M3s) are limited and controversial. Characterising the confounding factors that cause heterogeneity is important for evaluating the risks of the presence of M3s for individuals.

Estimating the mean prevalence of periodontal pathology of M2s with neighbouring M3s is the first step towards elucidating the relationship between the presence of M3s and the periodontal status of A-M2s, which contributes to M3 clinical decision making. Thus, this systematic review and meta-analysis aimed to synthesise and calculate the mean prevalence of periodontal pathology of A-M2s at the molar level, and to identify the confounding factors that lead to a high degree of variation in prevalence.

Materials and methods

The meta-analysis was performed according to the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines (Appendix 1, provided on request). The meta-analysis was not registered.

Literature search

The Cochrane Library, EMBASE and MEDLINE databases were searched systematically from inception to August 2020 using specific keywords. The keywords were described by wildcards and MeSH, and the following terms were combined in different databases: “third molar*”, “third-molar*”; “3rd molar*”; “wisdom tooth”; “wisdom teeth” and “second molar*”; “2nd molar*” “adjacent molar*”; “adjacent tooth”; “adjacent teeth” and “periodontitis”; “periodontal disease*”; “periodontal defects”; “periodontal destruction”; “periodontal pathology”; “periodontal inflammation”; “attachment loss”; “alveolar bone loss”; and “periodontal pockets”.

Study selection

Two investigators (YY and YT) independently reviewed and screened the searched articles. The selection process involved reading the titles and abstracts, reading the full articles and assessing the inclusion/exclusion of potentially qualified articles. In the event of ambiguities, detailed information was obtained by contacting the authors. Any disagreements were resolved through discussion or through consultation with a third investigator (LJS) to make the final decision. The inclusion criteria used for the systematic review were as follows:

- cross-sectional studies that evaluated the periodontal status of M2s with neighbouring M3s, regardless of being symptomatic or asymptomatic;
- studies defining the periodontal pathology of A-M2s either through clinical or radiographic examination;
- studies providing explicit information for calculating the prevalence of periodontal pathology of A-M2s at the molar level.

Reviews, case reports, case series, articles with full texts unavailable, studies with a sample size < 200 at the molar level and controversial studies without responses from authors were excluded. Studies involving specific populations such as pregnant women and orthodontic patients were also excluded, as were studies that screened the periodontal status.

Data extraction

The following data were extracted: basic information (first author, year of publication, journal and country), sample characteristics (study design, source of sample, sample number, sample age and sex and periodontal condition of sample), methods (clinical and/or radiographic examination), outcomes (prevalence of periodontal pathology of A-M2s at the molar level) and quality evaluation. CAL, ABL and PD were the most commonly reported parameters for evaluating periodontal status; thus, relevant data at the molar level were

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extracted to estimate the prevalence of periodontal pathology of A-M2s clinically and radiographically. Moreover, the prevalence of periodontal pathology of A-M2s under different M3 locations, M3 impaction status, patient sex and patient age was further extracted and listed below the overall prevalence. If one study reported the prevalence of periodontal pathology with more than one parameter, the following priority sequence was used for data extraction: CAL, ABL and PD. Only the preoperative data from studies that compared the clinical and radiological parameters before and after M3 surgery were extracted and used for statistical analysis. When the explicit prevalence of periodontal pathology was not reported directly, the prevalence was calculated by dividing the number of A-M2s with periodontal pathology by the total number of included A-M2s.

Assessment of study bias

We used the modified Newcastle-Ottawa scale (NOS), which was formulated for cross-sectional studies, to assess the bias of the included studies21. For cross-sectional studies, the NOS comprises sample selection, comparability among groups and outcome measurement, and there are detailed evaluation criteria for each item. Once the study met the evaluation criterion, it could be evaluated at one or two points depending on the evaluation standard. The maximum number of points was 10, and a study awarded a score higher than 7 was considered at low risk of bias. Bias was independently assessed by two investigators (YY and YT) and discussion was conducted to reach a consensus on the quality of the studies.

Data synthesis

For internal consistency and high efficiency in the meta-analysis, only studies that reported the prevalence of periodontal pathology for A-M2s with similar periodontal parameters were synthesised. CAL was defined as the distance from the cementoenamel junction to the base of the periodontal pockets greater than 3 mm22,23, and ABL as the distance from the cementoenamel junction to the alveolar bone greater than 3 mm or 20% root length24,25. These general definitions were used to explain the threshold values selected in this meta-analysis (CAL ≥ 3 mm, ABL ≥ 3 mm or 20% root length) for the presence of early periodontal defects. Moreover, at least one site with PD ≥ 5 mm was used to define the deep periodontal pockets around A-M2s10. The relevant data were imported into specific software (metafor package, meta package, in R statistical language, version 4.0.2, R Core Team, Vienna, Austria) for meta-analysis. Forest plots were used to describe the estimated effect size and 95% confidence interval (95% CI) for meta-analysis. The heterogeneity of the data was reflected by the Q-statistic and the I² test. If heterogeneity was significant (I² > 50% or P < 0.05), a random-effects model was used to calculate pooled data. Moreover, subgroup analyses according to different characteristics of M3s (M3 locations and impaction status) and patients (overall periodontal health, sex and age) were conducted to explore possible reasons for heterogeneity. If a sufficient number of studies were included, publication bias and sensitivity were assessed.

Results

In total, 865 records were identified using the search strategies. After removal of duplicates and title/abstract screening, 212 records were included for full-text screening. Based on the inclusion criteria, 193 records were excluded. Consequently, 19 studies were included for qualitative synthesis3,9-16,19,20,26-33, nine of which (14749 M3s) were used for meta-analysis (Fig 1)3,10-12,14,15,29,30,33.

Qualitative synthesis

Table 1 presents the main characteristics of all the included studies for qualitative synthesis. Only four of them used the general population as samples12-14,31; the others included patients in the analysis. The periodontal status of M2s was confirmed through clinical or radiographic examinations in five prospective studies that recruited participants and conducted data collection at a single time point1,10,13,30,31. Fourteen studies retrospectively evaluated the prevalence of periodontal pathology of M2s by collecting radiographic records9,11,12,14-16,19,20,26-29,32,33. Only two studies evaluated the overall periodontal health of participants using case definitions from the US Centers for Disease Control and Prevention (CDC) and the American Academy of Pediatrics (AAP), and most of their participants had mild or moderate periodontitis12,13. The periodontal status of A-M2s was evaluated using different periodontal parameters in the included studies. Thirteen studies reported the prevalence of ABL of A-M2s9,11,14-16,19,20,26-29,32,33 and eight described the specific degree of ABL, including ABL ≥ 1 mm19, 3 mm15,29,32, 5 mm16,32 or 20% root length11,14. Five selected studies used PD as a parameter to evaluate the periodontal status of A-M2s3,10,13,30,31, and in most cases, the measurement of at least one site of PD ≥ 5 mm around A-M2s was employed3,10,30. Only
seven studies compared the difference in prevalence between mandibular and maxillary M3s. Some of these found a higher prevalence with maxillary M3s than with mandibular M3s. The impaction status of M3s was analysed in different ways. Four studies reported the difference in periodontal pathology among different angulations of I-M3s according to the Winter classification. Even with different periodontal parameters, mesioangular and horizontal M3s were significantly associated with a higher risk of periodontal pathology than other angulations, and the risk for buccolingual and distal M3s was very low. Another four studies divided M3s into I-M3s (unerupted to the occlusal plane) and N-M3s (erupted to the occlusal plane) without explicit classifications of I-M3s and N-M3s, and three of them reported a higher prevalence of periodontal pathology with N-M3s. Different impaction depths and covered tissues associated with I-M3s were analysed but indicated weak evidence with limited studies. Additionally, four studies reported the prevalence of periodontal pathology between different age groups. Older age was associated with a higher risk of periodontal pathology than younger age, especially ≥ 30 years; only one study came to the opposing conclusion. Three studies reported a difference between sexes, but their results were completely different and showed no significant trend that sex influenced individuals' level of vulnerability to periodontal pathology of A-M2s.

**Quantitative synthesis**

Studies with similar periodontal parameters were included for the data synthesis. Six of those included in the qualitative synthesis evaluated the prevalence of early periodontal defects: CAL > 3 mm, ABL > 3 mm or ≥ 20% root length on distal sites of second molars with neighbouring third molars; analysis of deep periodontal pockets: at least one site with PD ≥ 5 mm around second molars with neighbouring third molars.
periodontal defects on distal sites of A-M2s with CAL ≥ 3 mm, ABL ≥ 3 mm or ≥ 20% root length, and three calculated the prevalence of deep periodontal pockets around A-M2s with at least one site with PD ≥ 5 mm, with subgroup analyses that were pooled and conducted separately. The data for other A-M2 sites and other periodontal parameters were not pooled due to the limited number of studies.

The results showed that the prevalence of early periodontal defects on distal sites of A-M2s was 19% (95% CI 9%–35%, I² 100%, P < 0.0001) (Fig 2) and the prevalence of deep periodontal pockets around A-M2s was 52% (95% CI 39%–64%, I² 97%, P < 0.01) with the random-effects method (Fig 3). Because the number of studies included in the meta-analysis was limited, we did not assess publication bias or conduct a sensitivity analysis.

Subgroup analyses on M3 locations

The prevalence of early periodontal defects on distal sites of A-M2s associated with mandibular M3s was 32% (95% CI 16%–54%, I² 99%, P < 0.01) (Appendix 3, provided on request). Meanwhile, a higher prevalence of deep periodontal pockets was recorded around A-M2s associated with mandibular M3s (62%, 95% CI 45%–76%, I² 96%, P < 0.01) (Appendix 4, provided on request) than maxillary M3s (43%, 95% CI 31%–56%, I² 94%, P < 0.01) (Appendix 5, provided on request), (odds ratio [OR] 2.21, 95% CI 1.67–2.92, I² 53%, P = 0.12) (Fig 4).

Subgroup analyses on M3 impaction status

No significant difference was found in the prevalence of early periodontal defects on distal sites of A-M2s between I-M3s (19%, 95% CI 10%–35%, I² 99%, P < 0.01) (Appendix 6, provided on request) and N-M3s (25%, 95% CI 12%–47%, I² 99%, P < 0.01) (Appendix 7, provided on request) (OR 1.04, 95% CI 0.71–1.54, I² 79%, P < 0.01) (Fig 5). Additionally, the prevalence of deep periodontal pockets around A-M2s with neighbouring N-M3s was 50% (95% CI 36%–64%, I² 97%, P < 0.01) (Appendix 8, provided on request).
Table 1  Data extraction of the main characteristics of the included studies for final review (cross-sectional studies).

<table>
<thead>
<tr>
<th>Study</th>
<th>Country</th>
<th>Journal</th>
<th>Study design</th>
<th>Source of sample</th>
<th>Number of participants</th>
<th>Sex</th>
<th>Number of molars</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chu et al[16]</td>
<td>China</td>
<td>Hong Kong Med J</td>
<td>Retrospective</td>
<td>Patients</td>
<td>2115</td>
<td>956 M, 1156 F</td>
<td>3178</td>
</tr>
<tr>
<td>Gupta et al[27]</td>
<td>India</td>
<td>J Family Med Prim Care</td>
<td>Retrospective</td>
<td>Patients</td>
<td>400</td>
<td>240 M, 160 F</td>
<td>640</td>
</tr>
<tr>
<td>Nivedita et al[10]</td>
<td>India</td>
<td>Minerva Stomatol</td>
<td>Retrospective</td>
<td>Patients</td>
<td>749</td>
<td>490 M, 259 F</td>
<td>2342</td>
</tr>
<tr>
<td>Nunn et al[14]</td>
<td>USA</td>
<td>J Dent Res</td>
<td>Retrospective</td>
<td>General population</td>
<td>416</td>
<td>NR</td>
<td>310</td>
</tr>
<tr>
<td>Prahabkar et al[31]</td>
<td>India</td>
<td>Biomed &amp; Pharmacol J</td>
<td>Prospective</td>
<td>General population</td>
<td>200</td>
<td>NR</td>
<td>400</td>
</tr>
<tr>
<td>Age, y</td>
<td>Periodontitis by AAP/CDC case definition</td>
<td>Diagnostic criteria of periodontal pathology of A-M2s</td>
<td>Prevalence of periodontal pathology of A-M2s Under different M3 locations, M3 impaction status, age of patients and sex of patients (if reported)</td>
<td>Risk of bias</td>
<td></td>
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<tr>
<td>Range 16–64, mean 26.42 ± 7.60</td>
<td>NR</td>
<td>DPT ABL &gt; 1 mm on distal sites of A-M2s</td>
<td>4.9% Mesial 10.6%, horizontal 9%, vertical 0.2%, others 4.7%</td>
<td>7</td>
<td></td>
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<tr>
<td>Range 20–25, mean 22.20 ± 1.80</td>
<td>NR</td>
<td>DPT ABL on distal sites of A-M2s</td>
<td>10.8% Male 9%, female 12.5%</td>
<td>7</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Range 14–45</td>
<td>AAP Class I–III</td>
<td>CE PD &gt; 5 mm on distal sites of A-M2s</td>
<td>6.1% At/above OP 6%, below OP 6% Vertical/distal 9.3%, mesial/horizontal 10.2% &lt; 25 y 2.9%, &gt; 25 y 9.3%</td>
<td>8</td>
<td></td>
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<tr>
<td>Range 17–89, mean 27.9</td>
<td>NR</td>
<td>DPT ABL &gt; 5 mm on distal sites of A-M2s</td>
<td>8.9% &lt; 30 y 5.7%, &gt; 30 y 16.3%</td>
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<td></td>
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<tr>
<td>Mean 27 y</td>
<td>NR</td>
<td>DPT ABL on distal sites of A-M2s</td>
<td>39.1%</td>
<td>6</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Range 25–92, mean 50</td>
<td>NR</td>
<td>DPT ABL on distal sites of A-M2s</td>
<td>3.1% Mandibular 4.5%, maxillary 1.2% Mesial 13.5%, horizontal 13.9%, vertical 1.3%, distal 1.1%, inverted 16.1%, buccal 0.0%</td>
<td>7</td>
<td></td>
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<tr>
<td>Mean 50</td>
<td>None or mild 48.8% Moderate 34.4% Sever 16.8%</td>
<td>Magnetic resonance imaging</td>
<td>32.8% Mandibular 43.5%, maxillary 24.2% I-M3s 27.9%, N-M3s 34.1%</td>
<td>7</td>
<td></td>
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<tr>
<td>Range 13–74, mean 29.00 ± 10.20</td>
<td>NR</td>
<td>DPT ABL on distal sites of A-M2s</td>
<td>10.8% &lt; 30 years &lt; 3%, &gt; 30 years &gt; 97%</td>
<td>7</td>
<td></td>
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<tr>
<td>Range 16–53, mean 27.20 ± 6.35</td>
<td>NR</td>
<td>DPT ABL &gt; 3 mm on distal sites of A-M2s</td>
<td>41.9% Male 56.22%, female 26.2%</td>
<td>7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≥ 19, mean 37.2</td>
<td>NR</td>
<td>DPT ABL ≥ 20% root length on distal sites of A-M2s</td>
<td>41.0% Mandibular 47.6%, maxillary 33.8% I-M3s 40.4%, N-M3s 41.5%</td>
<td>7</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Mean 40.60 ± 11.50</td>
<td>NR</td>
<td>CE PD &gt; 5 mm around A-M2s</td>
<td>51.6% Mandibular 57.9%, maxillary 44.2%</td>
<td>8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Range 18–83, mean 39.20 ± 12.80</td>
<td>NR</td>
<td>DPT ABL on distal and mesial sites of A-M2s</td>
<td>Distal sites 35.4% I-M3s 2.6%, N-M3s 38.9% Mesial sites 43.2% I-M3s 2.6%, N-M3s 47.6%</td>
<td>8</td>
<td></td>
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</tr>
<tr>
<td>Range 28.1–76.2, mean 45.80 ± 7.40</td>
<td>NR</td>
<td>DPT ABL ≥ 20% root length on distal sites of A-M2s</td>
<td>12.9% Soft tissue impaction 28%, bony impaction 16.9%, erupted 9.2%</td>
<td>7</td>
<td></td>
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</tr>
<tr>
<td>Range 21–25</td>
<td>NR</td>
<td>CE PD &gt; 4 mm on distal sites of A-M2s</td>
<td>12.0%</td>
<td>7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Range 18–60, mean 25.91 ± 6.34</td>
<td>NR</td>
<td>DPT ABL &gt; 3 mm on distal sites of A-M2s</td>
<td>Mesial 18.5%, horizontal 16.8%, vertical 0.9%, distal 0.0%, inverted 0% Class A 10.1%, class B 8.8%, class C 3.7%</td>
<td>6</td>
<td></td>
<td></td>
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</tbody>
</table>
Patient characteristics such as M3 impaction classification, overall periodontal health, sex and age were not fully reported or were not reported with similar periodontal parameters that could be used to conduct a subgroup analysis.

**Discussion**

Recently, the periodontal impacts of M3s on A-M2s have attracted increasing attention due to great controversy regarding clinical decision making concerning M3s. There is a general consensus that M3s should undergo long-term observation and ultimately removal if symptoms of disease are significant. On the other hand, it is not widely agreed that early treatment is necessary to prevent harm to A-M2s and avoid complications after removal in old age; however, a wide range of prevalence estimates of periodontal pathology of M2s with neighbouring M3s has been reported across studies due to methodological variations and different sample characteristics, and therefore cannot provide reliable evidence for clinical practice. To better understand the periodontal risks associated with M3s, this systematic review and meta-analysis was conducted. To our knowledge, this is the first meta-analysis on the prevalence of periodontal pathology of A-M2s.

The present meta-analysis appears to indicate that the prevalence of early periodontal defects on distal sites of second molars with neighbouring impacted third molars versus nonimpacted third molars.
periodontal pathology, and PD ≥ 5 mm has been confirmed to result in high levels of periodontal pathogens and inflammatory mediators in M3 regions\(^5\,3^{\text{8}}\).

In subgroup analyses, a higher prevalence of early periodontal defects was found to be associated with mandibular M3s (32%) than with M3s in general (19%), and the data on maxillary M3s were limited to be synthesised. However, both studies that analysed the difference between M3 locations reported a higher prevalence of early periodontal defects in mandibular than in maxillary molars\(^1^{\text{1}}\,1^{\text{2}}\). Moreover, the prevalence of deep periodontal pockets around A-M2s associated with mandibular M3s was significantly greater than that with maxillary M3s (OR 2.21). The higher odds of M3 impaction in mandibular than in maxillary regions could partly explain this difference\(^1\). Furthermore, subgroup analyses were conducted on M3 impaction status. Intriguingly, a higher prevalence of early periodontal defects was found to be associated with N-M3s (25%) than I-M3s (19%), even with no significant difference (OR 1.04). In the subgroup analysis, two studies reported a higher prevalence of N-M3s without explicit classifications of I-M3s\(^1^{\text{1}}\,1^{\text{2}}\), while Nunn et al\(^{14}\) reported that the prevalence of bony impacted and soft tissue impacted M3s was higher than that for N-M3s. The higher prevalence of N-M3s might be caused by the significant difference in the periodontal pathology between different impaction types\(^1^{\text{9}}\), which affected the overall prevalence associated with I-M3s. In the analysis of deep periodontal pockets around A-M2s, only one study reported separate outcomes for I-M3s and N-M3s\(^3\), which suggested a higher prevalence associated with I-M3s; however, the prevalence of deep periodontal pockets around A-M2s associated with N-M3s reached 50%, which reminds us that the presence of N-M3s is also an important periodontal risk factor for A-M2s. Additionally, some studies have reported other increased pathological parameters around A-M2s with N-M3s, such as Plaque Index and bleeding on probing\(^3\,1^{\text{0}}\).

Our meta-analysis indicated the periodontal risks associated with presence of M3s for A-M2s and highlighted which characteristics of M3s contributed to a higher prevalence of periodontal pathology of A-M2s. Considering the importance of M2s for masticatory function, clinicians need to examine the periodontal condition of A-M2s through clinical or radiographic assessment in regular oral examination, even in the absence of complaints about M3s and irrespective of the impaction status of M3s. The locations and impaction status of M3s should be taken into consideration to determine the best clinical decisions for individuals. It is worth noting that periodontal disease is always asymptomatic until the disease is severe\(^2^{\text{2}}\), so it is difficult to find periodontal pathology in M3 regions in the early stages of periodontitis. A number of studies have confirmed that asymptomatic M3s are closely related to the periodontal pathology of A-M2s\(^1^{\text{3}}\,1^{\text{7}}\,3^{\text{0}}\). More importantly, even with mechanical debridement, it is difficult to reduce the periodontal pathology in M3

<table>
<thead>
<tr>
<th>Age, y</th>
<th>Periodontitis by AAP/CDC case definition</th>
<th>Diagnostic criteria of periodontal pathology of A-M2s</th>
<th>Prevalence of periodontal pathology of A-M2s Under different M3 locations, M3 impaction status, age of patients and sex of patients (if reported)</th>
<th>Risk of bias</th>
</tr>
</thead>
<tbody>
<tr>
<td>Range 19–35, mean 36.80 ± 18.70</td>
<td>NR</td>
<td>CE PD &gt; 5 mm around A-M2s</td>
<td>38.5% Mandibular 46.1%, maxillary 29.8% I-M3s 42.9%, N-M3s 33.9%</td>
<td>9</td>
</tr>
<tr>
<td>Range 18–77, mean 29.30 ± 12.80</td>
<td>NR</td>
<td>DPT ABL &gt; 5 mm on distal sites of A-M2s</td>
<td>5.5% Mandibular 4.9%, maxillary 6.5% &lt; 30 y 6.9%, &gt; 30 y 1.2% Male 4.8%, female 4.9%</td>
<td>7</td>
</tr>
<tr>
<td>Range 20–83, mean 47</td>
<td>NR</td>
<td>DPT ABL &gt; 3 mm on distal sites of A-M2s</td>
<td>4.5%</td>
<td>6</td>
</tr>
<tr>
<td>Mean 35.10 ± 11.90</td>
<td>NR</td>
<td>CE PD &gt; 5 mm around A-M2s</td>
<td>64.5% Mandibular 78.3%, maxillary 55.5%</td>
<td>8</td>
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regions. Several studies have verified that removal of M3s contributes to improving the periodontal status of A-M2s, regardless of I-M3s or N-M3s, but older age and preoperative deep periodontal pockets lead to an unfavourable prognosis.

Nevertheless, the early stages of the periodontal pathology of M2s were evaluated in the meta-analysis. Estimates of severe periodontal pathology are available in only a limited number of studies, making it difficult to provide a convincing clinical decision regarding M3s. The periodontal status of M2s is affected by not only the presence of M3s but also other systemic factors, such as the presence of periodontitis, smoking status and diabetes. Considering the postoperative complications of M3 surgery, especially those involving chronic and irrecoverable symptoms such as paresthesia or temporomandibular joint disorder, removal of M3s should be conducted after comprehensive assessments, including of patients’ age, general health and oral hygiene and willingness to undergo surgery. Only when the benefits of M3 surgery outweigh the risks to individuals is removal of M3s required.

The limitations of the meta-analysis were the small number of studies for data synthesis and the inconsistent definition of early periodontal defects. Some of the studies included in the meta-analysis involved patients with symptomatic M3s; thus, these participants did not effectively reflect the characteristics of the general population and resulted in a higher estimate. In studies using radiographic examination methods, it was difficult to randomly include samples because of ethical concerns, and selection bias may systematically increase the prevalence of periodontal defects; however, we tried to provide the best possible estimates of the prevalence of periodontal pathology of A-M2s through rigorous selection. Large-scale, population-based studies are needed to further demonstrate the adverse periodontal impact of M3s on A-M2s, and confounding factors at the patient level should be discussed. Furthermore, there is a critical need to determine which factors of N-M3s contribute to the periodontal pathology of A-M2s.

Conclusion

This systematic review and meta-analysis indicated that M3s are associated with early periodontal defects on distal sites of A-M2s in 19% of cases and associated with deep periodontal pockets around A-M2s in 52% of cases. In subgroup analyses, mandibular M3s and N-M3s showed a higher prevalence and were identified as risk factors for periodontal pathology of A-M2s. However, these results should be interpreted with caution because of high heterogeneity; thus, comprehensive assessments are imperative in M3 clinical decision making.

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Conflicts of interest

The authors declare no conflicts of interest related to this study.

Author contribution

Dr Yang YANG acquired and interpreted the data and contributed to preparation of the manuscript; Drs Yi TIAN and Li Juan SUN contributed to the study design, data analysis and manuscript revision; Dr Hong Lei QU contributed to the study design.

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