THE CONSIDERATIONS OF MANDIBULAR INCISOR EXTRACTION IN ORTHODONTIC TREATMENT: A SYSTEMATIC REVIEW

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ABSTRACT

In orthodontics, extraction remains a controversial and multidisciplinary choice. In some instances, the understanding of the treatment outcomes and relapse rate has its importance. However, different literature needs to be assessed on the effectiveness of mandibular incisal extraction (MIE) among non-growing patients as an alternative treatment modality. This review was done following a particular focus question: “Is mandibular incisor extraction being a common choice in orthodontic treatment planning to resolve the crowding among non-growing patients?” under the PICO standards. Data selection strategy followed the methodology of PRIZMA guidelines using keywords. Studies in humans that included MIE, published in high impact journals, in the English language, from 2015 to 2020, among non-growers from both genders were included. However, irrelevant studies to the current review, case reports, systematic reviews, opinions, and survey-based cross-sectional studies were excluded following strict eligibility criteria.

From different electronic databases "Saudi Digital Library, Clarivate, Cochrane Library, Google Scholar, and Pubmed". 6273 studies were identified, 1668 were recorded after duplicates were removed. Subsequently, going through the title and abstract, 1653 were eliminated due to multiple reasons. 15 articles were read in the full test; only 8 articles were chosen after qualitative assessment. The risk of bias was apprised by one reviewer as all provided level I & II evidence. Significant agreement about the most frequent indications of MIE was mandibular crowding and skeletal class III camouflage. An unclear correlation was found between MIE, premolar extraction in terms of post-treatment relapse.

Key words: Mandibular incisor, Extraction, Bolton discrepancy, Orthodontics, review.

Introduction

In orthodontics, the extraction of a tooth or several teeth to obtain a functional, harmonious, and normal occlusion has been clinically observed and studied through scientific research [1, 2]. Furthermore, the purpose of orthodontic extraction is to gain space in the arch to correct proline teeth or crowding. Tooth extraction for orthodontic treatment remains a controversial topic, and treating all malocclusions without extraction is impossible [3]. The decision to extract teeth for orthodontic treatment is a multidisciplinary choice. Edward H. the angle has stated in 1907 that "moving teeth into normal occlusion with orthodontic forces would cause the jaws and associated bones to grow to accommodate the increase in the size of the dentures". On the other hand, Calvin Case had a different opinion about the stability of the orthodontic treatment without extractions, which was not often achieved. In the 1930s, many cases with non-extraction treatment have been observed by the practitioners started to relapse [4].

Each type of malocclusion has its sequence of extraction depending on the patient acceptance and the case. For Angle class I with crowding, protrusion, or open bite extraction of the first bicuspid in the upper and lower arch is an option. Besides, the extraction of the first upper bicuspid is for Angle class II; furthermore, the extraction of the first upper bicuspid and second lower bicuspid is for Angle class II with excessive overjet or crowding. Moreover, for Angle class III, first, lower bicuspid is extracted [5].

Wayne A Bolton has developed an association that influences the relationship between maxillary and mandibular jaws regarding the mesiodistal size of teeth in dental arches [6]. Traditionally, an ideal occlusion is considered the ultimate gold standard for the assessment of orthodontic treatment outcomes. However, before reaching a favorable treatment choice, the orthodontist should consider the esthetic demand, stability, occlusion to be accomplished, and treatment goal of each patient [1].

Many case reports discuss mandibular incisor extractions (MIE) as an orthodontic treatment in resolving the crowding [7]. However, they are deficient in supporting literature of high-qualitative randomized and/or nonrandomized clinical trials as well as prospective and/or retrospective cohort studies. This current systemic review aimed to systematically assess the available literature on
the effectiveness of MIE as an alternative orthodontic treatment while having a clear understanding of its outcomes, relapse rate, and emphasizing its importance in certain cases.

**Materials and Methods**

**Eligibility criteria**
High-impact journal articles that were published from 2015 to May 2020 limited in English that covered MIE in humans were included. Prospective retrospective cohort studies, randomized, and nonrandomized clinical trials with an average age group of non-growing patients in both genders were included (Table 1). The justification of all excluded studies was as follows: aims irrelevant to the current study, case reports, systemic reviews, opinions, cross-sectional survey-based studies, or didn’t meet our age group criteria (Figure 1).

**Information sources, search strategy, and study selection**
After obtaining the ethical approval from the IRB committee of Riyadh Elm University SRS/2020/8/189. Five electronic databases (PubMed, Google Scholar, The Cochrane Library, Clarivate, and Saudi Digital Library (SDL)) were searched. The search strategy for data selection followed the methodology by the guidelines of PRISMA as represented in Figure 1.

The search was done in two stages following a particular focus question under the PICO standards: “Is mandibular incisor extraction being a common choice in orthodontic treatment planning to resolve the crowding among non-growing patients?”.

In the first stage, the following keywords were included: (Extraction of mandibular incisors), (Orthodontic mandibular incisors), and (anterior crowding).

Then in the second stage, (Bolton discrepancies) were added, since we noticed a lack of literature covered that concerning mandibular incisor extraction, and to prevent any limitation in review outcomes.
Data collection was done by one particular reviewer (First Author) evaluated the methodological quality of the articles after the final assessment of the full text (n=15) independently. Accordingly, 8 final articles were individually applied to clear our eligibility criteria, as shown in Table 1.

### Table 1. Review eligibility criteria

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Inclusions</th>
<th>Exclusions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type of study</strong></td>
<td>In human studies</td>
<td>Animal studies</td>
</tr>
<tr>
<td></td>
<td>Randomized and nonrandomized clinical trials</td>
<td>Case reports</td>
</tr>
<tr>
<td></td>
<td>Prospective and/or retrospective cohort studies.</td>
<td>Systemic review</td>
</tr>
<tr>
<td><strong>Sources</strong></td>
<td>Journal high impact factor</td>
<td>Survey-based cross-sectional studies</td>
</tr>
<tr>
<td><strong>Year of publication</strong></td>
<td>From 2015- May 2020</td>
<td>The unsupported opinion of the expert or replies to the author/editor.</td>
</tr>
<tr>
<td><strong>Language</strong></td>
<td>English language</td>
<td>Books/conferences/abstracts</td>
</tr>
<tr>
<td><strong>Age group</strong></td>
<td>The average age of non-growing patients.</td>
<td></td>
</tr>
<tr>
<td><strong>Dentition</strong></td>
<td>Permanent dentition</td>
<td></td>
</tr>
<tr>
<td><strong>Treatment protocol</strong></td>
<td>Mandibular incisors extraction in comparison to other treatment modalities.</td>
<td>Extractions of any other teeth, expansion, interproximal reduction (IPR), and/or distalization alone.</td>
</tr>
<tr>
<td><strong>Cases</strong></td>
<td>Moderate and/or Sever discrepancy/Crowding</td>
<td>Spacing</td>
</tr>
<tr>
<td><strong>Intervention</strong></td>
<td>Conventional orthodontic appliances and/or clear aligners</td>
<td>Open-bite</td>
</tr>
<tr>
<td><strong>Outcome measures</strong></td>
<td>The primary outcomes were measured dentoalveolar and soft tissue correction, including clinical, study model, and/or radiographical measurements and the duration of treatment.</td>
<td>Crossbite and other skeletal problems</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3D radiography</td>
</tr>
</tbody>
</table>

### Summary measures and approach to synthesis

Quality assessment of the 8 final articles was appraised for risk of bias by one independent reviewer using a well-formulated quality assessment tool, (The Cochrane Tool). Sampling bias was appraised by assessing and evaluating the sample selection, performance, detection of outcome assessors, attrition, and reporting. The overall assessment provided ranges from low to moderate bias risk for the 8 articles; Table 2 summarizes the main methodological points of these articles.

### Table 2. Criteria for judging the risk of bias in the 'Risk of bias' assessment tool – reproduced from The Cochrane Tool

<table>
<thead>
<tr>
<th>Bias Type</th>
<th>Bias</th>
<th>Kaya, et al., 2015</th>
<th>Mahmoudzadeh, et al., 2018</th>
<th>Lee, et al., 2019</th>
<th>Kamal et al., 2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>Selection</td>
<td>Random Sequence Generation</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>Allocation Concealment</td>
<td>Unclear</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Performance</td>
<td>Blinding of Personneland Participants</td>
<td>High</td>
<td>Unclear</td>
<td>Unclear</td>
<td>Unclear</td>
</tr>
<tr>
<td>Detection</td>
<td>Blinding of Outcome Assessors</td>
<td>UnCleaf</td>
<td>High</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Attrition</td>
<td>Incomplete Outcome Data</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Reporting</td>
<td>Selective Reporting</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Overall Assessment</td>
<td>Moderate</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Bias Type</th>
<th>Bias</th>
<th>Vilhjalmsson, et al., 2019</th>
<th>Antoszewska-Smith, et al., 2017</th>
<th>Khan, et al., 2017</th>
<th>Suleman, et al., 2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>Selection</td>
<td>Random Sequence Generation</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>Allocation Concealment</td>
<td>Unclear</td>
<td>Unclear</td>
<td>Unclear</td>
<td>Unclear</td>
</tr>
</tbody>
</table>
Performance | Blinding of Personnel and Participants | Unclear | Unclear | Unclear | Unclear | Unclear | Unclear |
---|---|---|---|---|---|---|---|
Detection | Blinding of Outcome Assessors | High | Unclear | Unclear | Unclear | Unclear | Unclear |
Attrition | Incomplete Outcome Data | Low | Low | Low | Low | Low | Low |
Reporting | Selective Reporting | Low | Low | Low | Low | Low | Low |

Overall Assessment | Moderate | Moderate | Moderate | Moderate | Moderate | Moderate |

Criteria of judgment following unclear, high, or low risk was judged as follows: 1. Incomplete outcome data: attrition bias due to handling, nature, or amount of incomplete outcome data. 2. Selective reporting: reporting bias as a result of selective outcome reporting. 4. Blinding of outcome evaluation: detection bias as a result of the outcome assessors’ knowledge of allocated interventions. 3. Blinding of personnel and participants: performance bias as a result of personnel and participants’ knowledge of the allocated interventions. 2. Allocation concealment: selection bias (biased allocation to interventions) as a result of inadequate concealment of assignments before evaluation. 1. Random sequence generation: selection bias (biased allocation to interventions) as a result of inadequate generation of a randomized sequence.

Results and Discussion

The search of the literature has identified 6273 studies. One thousand six hundred sixty-eight studies were recorded after removing the duplicates. Subsequently, going through the title and abstract of the obtained literature, 1653 were eliminated due to multiple reasons: Irrelevant aim of the study, case report, systemic review, opinions, or survey-based cross-sectional studies. The full text of fifteen articles was read and 8 were chosen after a qualitative assessment that matched strict eligibility criteria. Numerically, the rest are mentioned in the “Prisma Flow Diagram” (Figure 1). The final eight articles included 2 retrospective studies, 4 retrospective and cross-sectional studies, and 2 descriptive, retrospective, and cross sectionals. One article was presented as the control group. The data from groups of interest were extracted from the articles.

Table 3. Characteristics of included studies. NA: Not Applicable, MIE: Mandibular incisor extraction, PAR: Peer Assessment rating, PME: Premolar extraction, NE: Non-extraction

<table>
<thead>
<tr>
<th>Authors</th>
<th>Study type</th>
<th>Setting</th>
<th>Sample size</th>
<th>Parameters measured</th>
<th>Treatment appliance used</th>
<th>Retention</th>
<th>Post-retention</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kaya, B et al., 2015</td>
<td>Retrospective study</td>
<td>Department of Orthodontics, Başkent University</td>
<td>N=32 (18F/14M) mean age: 20±4.6 years; Group 1: 16 patients (9F/7M) mean age: 19.4±3.4 years; Group 2: 16 patients (9F/7M) mean age: 19.3±3.4 years; treated with four first premolar extractions.</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>
Mahmoudzadeh, M. et al., 2018
Retrospective cross-sectional study
Hamedan University of Medical Science, Hamedan, Iran

N=120 (99F/21M)
Group 1: 40 patients treated with single mandibular incisor extraction (31F/9M) mean age 21.62 ± 4.7
Group 2: 40 patients treated with No extraction (33F/7M) mean age 24.87 ± 6.3
Group 3: 40 patients treated with Premolar extraction (35F/5M) mean age 22.9 ± 5.8

None

Post retention impressions were obtained from the patients and the casts were compared in 3 times: before the treatment, after the treatment, and ≥2 years after retention with a mean of 3.5 years

Treated using MBT prescription straight wire appliance (slot size of 0.028×0.022 inches)

74 (61.7%) using Hawley retainers, and 46 (38.3%) using clear retainers.

Duration:
- Single extraction group: 8.6 ± 4.9
- Non-extraction group: 7.2 ± 4.1
- Premolar extraction group: 8.4 ± 5.1

Duration:
- Single extraction group: 3.35 ± 0.9
- Non-extraction group: 3.5 ± 2.13
- Premolar extraction group: 3.2 ± 1.11

Treatment modality in terms of extraction or non-extraction is not the main determinant in post-treatment relapse.

Lee, S et al., 2019
Retrospective cross-sectional Study
The University of Otago.

N=14 (5F/9M)
Treated with mandibular incisor extraction.
Mean age 16.0 ± 4.4 years
Treatment duration of 19.5 ± 6.4 months

N=14 (9F/5M)
treated without extractions
Mean age 15.8 ± 3.9 years
Treatment duration of 18.0 ± 4.4 months

Clinical history (pre- and post-treatment study casts, intraoral photographs, and wax setups) of those undergoing orthodontic postgraduate students

Full fixed appliances

NA

74 (61.7%) using Hawley retainers, and 46 (38.3%) using clear retainers.

Duration:
- Single extraction group: 8.6 ± 4.9
- Non-extraction group: 7.2 ± 4.1
- Premolar extraction group: 8.4 ± 5.1

Duration:
- Single extraction group: 3.35 ± 0.9
- Non-extraction group: 3.5 ± 2.13
- Premolar extraction group: 3.2 ± 1.11

Treatment modality in terms of extraction or non-extraction is not the main determinant in post-treatment relapse.
<table>
<thead>
<tr>
<th>Study</th>
<th>Participants</th>
<th>Methods</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kamal, A.T et al., 2017</td>
<td>N:108 patients</td>
<td>Retrospective cross-sectional study</td>
<td>PAR index was used to assess the pre- and post-treatment dental casts for each of the subjects.</td>
</tr>
<tr>
<td></td>
<td>Group 1: 36 patients treated with premolar extractions with a mean age of 19.2 ± 3.6 years.</td>
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<td>Group 2: 36 patients treated with no extraction with a mean age of 18.9 ± 4.1 years.</td>
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<td></td>
<td>Group 3: 36 patients treated with 1 mandibular incisor extraction with a mean age of 19.0 ± 2.3 years.</td>
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<tr>
<td></td>
<td>None</td>
<td></td>
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</tr>
<tr>
<td>Vilhjalmsson, G et al., 2019</td>
<td>N:37 patients (25F/12M) and the age of the patients is</td>
<td>Retrospective study</td>
<td></td>
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<tr>
<td></td>
<td>Age &lt;20 years, 25 patients</td>
<td></td>
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<tr>
<td></td>
<td>Age 20-40 years, 9 patients</td>
<td></td>
<td></td>
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<td></td>
<td>Age &gt;40 years, 3 patients</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>None</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Effectiveness and treatment time of the treatment.</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Comprehensive orthodontic appliance and extraction site preparation</td>
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<tr>
<td></td>
<td>In one case of the 37 patients, retention was mentioned</td>
<td></td>
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<tr>
<td></td>
<td>in case 1. Bonded retainers</td>
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<td></td>
<td>In one case of the 37 patients, post retention was mentioned</td>
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<tr>
<td></td>
<td>in case 1. 4-year recall, with excellent stability.</td>
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</table>
In this systemic review, different kinds of literature were evaluated regarding MIE in the form of resolving crowding among non-growing orthodontic patients; that included their long-term stability, relapse rates, profile, and aesthetic outcomes. Therefore, in addition to different treatment modalities such as non-extraction forms of arch expansion, premolar extraction, and interproximal reduction (IPR), articles that were included in this paper were provided with level 1 & II evidence, which is considered a great strength. All eight articles included the topic of mandibular incisors extraction and their outcomes [8-13]. Three were compared in terms of premolar extraction and mandibular incisor extraction and mandibular incisor extraction [8-13]. Two showed various extraction patterns and MIE as well as different treatment approaches. All information regarding the author, year, setting, sample, treatment appliance used, parameters measured, study type, post retention, and strength of evidence was collected from the included articles and described in (Table 3).

All eight articles included the topic of mandibular incisors extraction and their outcomes [8-13]. Three were compared in terms of premolar extraction and mandibular incisor extraction [8-13]. Two showed various extraction patterns and MIE as well as different treatment approaches. All information regarding the author, year, setting, sample, treatment appliance used, parameters measured, study type, post retention, and strength of evidence was collected from the included articles and described in (Table 3).

Group 1: dental arch expansion
Group 2: interproximal enamel reduction
Group 3: 1 lower incisor extraction

The lowest value of retention was found in group 1 and the highest was found in group 3.

After one year of retention, there was a major relapse occurred following expansion (group 1) and after interproximal enamel reduction (group 2).

Group 3 displayed no relapse.
Burgak Kaya et al. compared cephalometric measurement, maxillary and mandibular space analysis and irregularities, Bolton excess in mandible, and skeletal, dental, and soft tissue. As a result, mandibular lower incisor extraction can be a more conservative approach than four premolar extractions in cases that demands localized treatment and little change in the dental arch. Since it showed at the end of both treatments no significance sagittal skeletal changes and overjet and overbite remained unchanged, but the study lacked in mentioning the relapse rate of both treatments [14].

On the other hand, different outcomes were found in a study focused on the long-term stability in 3 different treatment modalities in resolving mandibular incisor crowding among 3-time points: before the treatment, after the active treatment, and ≥2 years following retention with a mean of 3.5 years. They found that relapse of crowding was obvious in all treatments, and there wasn’t a major correlation between different treatment approaches and post-treatment relapse [15].

Gisli Vilhjalmssson et al. shed light on significant objectives that concern the dentist while following this approach; black triangles, tooth discrepancies, and patient concern of the visible site of extraction. They described how to overcome those by simply lingual tipping of the mandibular incisor before extraction, which showed an almost 100% success rate with patients under 20 that had no black triangles before the treatment. Yet this approach may extend the treatment time 2-6 months—none the less this study was localized to the Icelandic population and lacked other populations. If different populations that are known for their poor oral hygiene were included, they might have different results, since black triangles are periodontal multifactorial [9].

Multiple studies used the Peer Assessment Rating (PAR) index which is considered a reliable and valid tool in orthodontics; to assess the pre- and post-treatment dental casts after treatment modalities [8, 16]. Though PAR index had some limitations; it lacked consideration of patient’s satisfaction, periodontal and dental health, functional occlusion, cephalometric changes, and soft tissue profiles [4].

Sherry Lee et al. analyze clinical records pre- and post-treatment study casts, intraoral photographs, and wax setups to compare treatment attractiveness between non-extraction controls and MIE cases. The results indicated that in carefully selected cases, the extraction of a mandibular incisor might lead to proper outcomes that are considered as attractive as those handled without extraction, and with a longitudinal evaluation which was an advantage to the study [8]. While J. Antoszewska-Smith et al. assessed the reliability of Little's Irregularity Index and established an effective algorithm for the treatment of adult patients with crowding in the mandibular front area [10, 18].

Waheed Ullah Khan et al. determined the prevalence of crowding, frequency, and pattern of extraction [17]. Extraction of a tooth and treatment planning for orthodontic treatment can be influenced by many factors such as good patient cooperation, appliance selection, and management of the treatment for achieving functional, stable occlusion and aesthetic outcome. The main indications to extract the mandibular incisor are lower anterior crowding or protrusion anomalies in the number, size, class III malocclusion, Class I malocclusion with anterior tooth size discrepancies and severe mandibular anterior segment crowding, improve aesthetic, edge-to-edge occlusion, ectopic eruption, open bite and crossbite of anterior teeth, periodontally compromised incisors, lower anterior Bolton’s excess greater than 4 mm and for Class II Mandibular single incisor extraction should be combined with maxillary premolar extractions in order to establish normal occlusion and overjet [9, 11, 14-17, 19, 20].

Moreover, MIE contraindications are anterior maxillary tooth size excess, deep overbite, periodontal diseases, and triangular-shaped mandibular incisors [19]. The advantages of one MIE are: maintaining the overall arch form, reduce cost, diminish the relapse in the anterior region, minimizing the change in profile and treatment time [8, 11, 14, 16, 21, 22]. However, clinical experience, diagnostic wax setup, and initial records are factors that should be considered before the final decision to extract the mandibular incisor [23].

Nevertheless, the disadvantages are acceptable aesthetic, midline discrepancy, differences between adjacent teeth in the shade, increases in the loss of the interdental gingival papillae, space reopening, crowding recurrence, unsatisfactory posterior occlusion, and overbite in the mandibular anterior region. In case there is no Bolton discrepancy exist, an increase in the overjet will exist [8, 14, 17, 21].

Conclusion

Several conclusions can be drawn on the indications and different impacts of mandibular incisor extraction (MIE) as an alternative for orthodontic purposes.

There was a significant agreement about the most frequent indication of MIE in moderate to severe mandibular anterior crowding, as well as a camouflage of skeletal class III cases with a mild anterior crossbite, mainly when an excellent posterior intercuspation is present.

An unclear correlation was detected between MIE or PME in terms of post-treatment relapse rate. However, multiple studies, showed that MIE could be a more effective and conservative alternative to PME in cases where limited
treatment and little changes in the dental arch are required, particularly among adults.

Furthermore, the major problem with MIE is black triangles (that are caused by loss of interdental papilla height), tooth size discrepancy, and patient concern of visible site of extraction. This was simply solved by lingual tipping of the mandibular incisor before extraction. Clinicians should be aware of the factors that influence the choice of teeth extraction in orthodontic cases, in order to achieve proper treatment management with excellent patient cooperation, as well as achieving best esthetics, functional, and stable occlusion.

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Conflict of interest: None

Financial support: None

Ethics statement: Ethical review and approval were obtained from the institutional review board (IRB) of Riyadh Elm University, Riyadh, KSA and a registration no SRS/2020/8/189 is assigned.

References
