Review Article

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

Nancy Ajwa[1], Hadeel Albarkheel[2], Luluh Alammar[3], Aldanah Alwoseamer[3], Arwa Alhassoun[2], Joud Aljoudi[3]*

[1] Orthodontics Division, Preventive Dentistry Department, College of Dentistry, Riyadh Elm University, Riyadh, KSA.nancy.ajwa@riyadh.edu.sa
[2] College of Dentistry, King Saud bin Abdulaziz University for Health Sciences, Riyadh, KSA.
[3]College of Dentistry, Riyadh Elm University, Riyadh, KSA.

https://doi.org/10.51847/oFHM5pCzUw

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 crowing 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 bicuspids in the upper and lower arch is an option. Besides, the extraction of the first uppers bicuspids is for angle class II; furthermore, the extraction of the first upper bicuspids and second lower bicuspids is for angle class II with excessive overjet or crowding. Moreover, for Angle class III, first, lower bicuspids are 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)**.

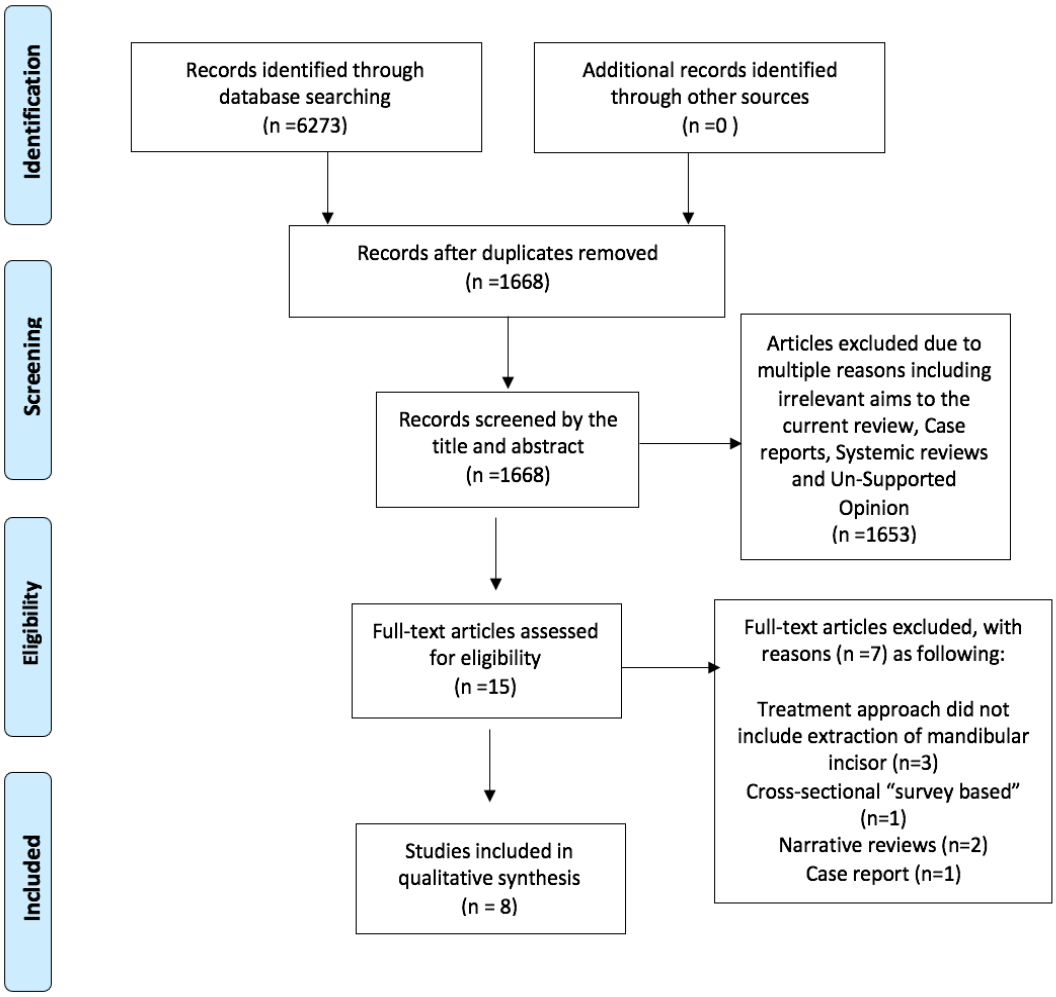

Figure 1. Prisma Flow diagram

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 items and collection

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

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

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

Bias Type	Bias	Kaya, et al., 2015	Mahmoudzadeh, et al., 2018	Lee, et al., 2019	Kamal et al., 2017
Selection	Random Sequence Generation	Low	Low	Low	Low
	Allocation Concealment	Unclear	Low	Low	Low
Performance	Blinding of Personneland Participants	High	Unclear	Unclear	Unclear
Detection	Blinding of Outcome Assessors	Unclear	High	High	High
Attrition	Incomplete Outcome Data	Low	Low	Low	Low
Reporting	Selective Reporting	Low	Low	Low	Low
Overall Assessment		Moderate	Low	Low	Low
Bias Type	Bias	Vilhjálmsson, et al., 2019	Antoszewska-Smith, et al., 2017	Khan, et al., 2017	Suleman, et al., 2018
Selection	Random Sequence Generation	Low	Low	Low	Low
	Allocation Concealment	Unclear	Unclear	Unclear	Unclear

Performance	Blinding of Personneland Participants	Unclear	Unclear	Unclear	Unclear
Detection	Blinding of Outcome Assessors	High	Unclear	Unclear	Unclear
Attrition	Incomplete Outcome Data	Low	Low	Low	Low
Reporting	Selective Reporting	Low	Low	Low	Low
	Overall Assessment	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.

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.

Results and Discussion

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

				Sample size		Method			
	Authors	Study type	Setting	Age characteristic	Controls	Parameters measured	Treatment appliance used	Retention	Post-retention
1	Kaya, B et al., 2015	Retrospective study	Department of Orthodontics, Başkent University	N=32 (18F/14M) Group 1: 16 patients (9F/ 7M) mean age 20±4.6 years; treated with 1 mandibular incisor extraction. Group2: 16 patients (9F/7M) mean age: 19.4±3.4 years; treated with four first premolar extractions	None	Maxillary space analysis, mandibular space analysis, maxillary irregularity, mandibular irregularity, Bolton excess in the mandible and dental, skeletal, and soft tissues. Cephalometric between- and within-group comparisons.	Orthodontic treatment with 0.022×0.018-inch slot edgewise appliances. Duration: Group1: 18.3 ± 4.2 months Groups 2: 25.0 ± 5.6 months treatment time was significant	NA	NA

2	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
3	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 undergoingorthodontic postgraduate students

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.
Clinical history(pre- and post-treatment study casts, intraoral photographs, and wax setups) of those undergoingorthodontic postgraduate students	Full fixed appliances	NA NA

4	Kamal, A.T et al., 2017	Retrospective cross-sectional study	Dental clinics at AgaKhan University Hospital, Karachi, Pakistan.	N:108 patients Group 1:36 patients treated with premolar extractions with a mean age of 19.2 ± 3.6 years. Group2: 36 patients treated with no extraction with a mean age of 18.9 ± 4.1 years Group3: 36 patients treated with 1 mandibular incisor extraction with a mean age of 19.0±2.3 years	None	PAR index was used to assess the pre- and post-treatment dental casts for each of the subjects.	Orthodontic treatment with the straight-wire appliance 0.022 ± 0.028-in Roth prescriptions in both arches	NA	NA
5	Vilhjálmsson, G et al., 2019	Retrospective study	The University of Connecticut or in 6 private practices	N:37 patients (25F/12M) and the age of the patients is Age<20years, 25 patients Age 20-40 years, 9 patients Age>40 years, 3 patients.	None	Effectiveness and treatment time of the treatment.	Comprehensive orthodontic appliance and extraction site preparation	In one case of the 37 patients, retention was mentioned in case1. Bonded retainers	In one case of the 37 patients, post retention was mentioned in case 1. 4-year recall, with excellent stability.

6	Antoszewska-Smith, J et al., 2017	Retrospective cross-sectional study	Department of Dentofacial Orthopedics and Orthodontics and Department of Prosthodontics, Wroclaw Medical University, Wroclaw, Poland	N=302 patients Group 1: Less than 3mm dentoalveolar-discrepancy treated with the dental arch expansion, 100 patients Group2: From 1 to <5mm dentoalveolar discrepancy treated with interproximal enamel reduction, 101 patients Group3:>5mm dentoalveolar discrepancy treated with extraction of 1 lower incisor, 101 patients	None	Assessment of the reliability of Little’s Irregularity Index and establishing an effective algorithm for the treatment of adult patients with crowding in the mandibular front area.	Group1: dental arch expansion Group2: interproximal enamel reduction Group3: 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 (group1) and after interproximal enamel reduction (group2). Group 3 displayed no relapse
7	Khan, W.U et al., 2017	Descriptive, retrospective cross-sectional	Department of Orthodontics, Islamabad Dental Hospital.	N=916 Group1:10-15 years Group2:16-20 years Group3:21-25 years Group4:26-30 years Group5:31-35 years	None	Prevalence of crowding, frequency and pattern of extraction	Different pattern of extraction	NA	The post-retention alignment was more favourable in single-incisor (71%) and two-incisor (44%) extraction cases as compared to premolar extraction cases (30%).
8	Suleman, S et al., 2018	A descriptive, retrospective cross-sectional study	Department of Orthodontics, Islamabad Dental Hospital.	N=92 (43F/49M) mean age of patients in was 20 years	None	Frequency of various indications for mandibular incisor extraction	NA	Greater stability in the anterior region has Been reported after mandibular single incisor extraction	The extraction of lower incisor has a great post treatment stability

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 esthetic outcomes. Therefore, in addition to different treatment modalities such as non-extraction forms of arch expansion, premolar extraction, and interproximal reduction (IPR), MIE alongside and its outcomes were also considered. All articles that were included in this paper, were provided with level I & II evidence, which is considered a great strength. The full quality assessment is mentioned in **(Table 2)**.

All eight articles included the topic of mandibular incisors extraction that matches the focus question of the current systemic review. Four described mandibular incisor extraction [8-13]. Three were compared in terms of premolar extraction and mandibular incisor extraction and their outcomes [14-16]. Two showed various extraction patterns and MIE as well as different treatment approaches, including IPR and dental arch expansion [10, 17]. All information regarding the author, year, setting, sample, retention, treatment appliance used, parameters measured, study type, post retention, and strength of evidence, was collected from the included articles and described in **(Table 3)**.

Burçak 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 ≥2years 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].

Gısli Vilhjalmsson 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 4mm 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.

Acknowledgments: The authors thank the Institutional Review board and the research center at Riyadh Elm University for their continuous support.

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

1. Matsumoto MA, Romano FL, Ferreira JT, Tanaka S, Morizono EN. Lower incisor extraction: An orthodontic treatment option. Dental Press J Orthod. 2010;15(6).
2. Rafighi A, Sohrabi A, Moslemzadeh SH, Mardani Z. Assessing Pain and Cooperation Levels of Orthodontic Patients Treated with Medium and Heavy Intermaxillary Elastics: a Randomized Clinical Trial. Arch Pharm Pract. 2019;10(1):19-30.
3. Wala Dhafar BD, Rafif Mandura BD, Amal Dafar BD, Mohammed Alghamdi BD. Reasons for Third Molars Extraction by Different Health Care Providers. Int J Pharm Res Allied Sci. 2020;9(2):189-94.
4. Holman JK, Hans MG, Nelson S, Powers MP. An assessment of extraction versus nonextraction orthodontic treatment using the peer assessment rating (PAR) index. Angle Orthod. 1998;68(6):527-34.
5. Morón Duelo R, Marcianes Moreno M, De la Cruz Fernández C, Domínguez-Mompell Micó R, García-Camba VarelaP, Varela Morales M. Extractions in Orthodontics: An update. Span Cient Dent. 2015;12(1):32-41.
6. Cancado RH, Goncalves Junior W, Valarelli FP, Freitas KM, Crêspo JA. Association between Bolton discrepancy and Angle malocclusions. Braz Oral Res. 2015;29(1).
7. Safavi SM, Namazi AH. Evaluation of mandibular incisor extraction treatment outcome in patients with Bolton discrepancy using peer assessment rating index. J Dent (Tehran, Iran). 2012;9(1):27.
8. Lee S, Firth FA, Bennani F, Harding W, Farella M, Antoun JS. Evaluation of objective and subjective treatment outcomes in orthodontic cases treated with extraction of a mandibular incisor. Angle Orthod. 2019;89(6):862-7.
9. Vilhjálmsson G, Zermeno JP, Proffit WR. Orthodontic treatment with removal of one mandibular incisor: Outcome data and the importance of extraction site preparation. Am J Orthod Dentofacial Orthop. 2019;156(4):453-63.
10. Antoszewska-Smith J, Bohater M, Kawala M, Sarul M, Rzepecka-Skupień M. Treatment of Adults with Anterior Mandibular Teeth Crowding: Reliability of Little's Irregularity Index. Int J Dent. 2017;2017.
11. Suleman S, Khan WU, Yousafzai IK, Shafique S, Gul T. Various reasons of mandibular incisor extraction in orthodontic patients. Pakistan Orthod J. 2018;10(2):111-5.
12. Dardengo CD, Fernandes LQ, Capelli Júnior J. Frequency of orthodontic extraction. Dental Press J Orthod. 2016;21(1):54-9.
13. Afridi S, Pasha A, Mahmood A. Prevalence of lower incisor crowding in Pakistani population using Little's Irregularity Index. Pakistan Orthod J. 2011;3(2):44-8.
14. Kaya B, Polat-Özsoy Ö, Erken S, Özsoy FS. Assessment of dentofacial effects of lower incisor versus 4 premolar extractions. Int J Oral Dent Health. 2015;1:4.
15. Mahmoudzadeh M, Mirzaei H, Farhadian M, Mollabashi V, Khosravi M. Comparison of anterior crowding relapse tendency in patients treated with incisor extraction, premolar extraction, and nonextraction treatment. J World Fed Orthod. 2018;7(2):61-5.
16. Kamal AT, Shaikh A, Fida M. Improvement in Peer Assessment Rating scores after nonextraction, premolar extraction, and mandibular incisor extraction treatments in patients with Class I malocclusion. Am J Orthod Dentofacial Orthop. 2017;151(4):685-90.
17. Khan WU, Ijaz M, Ijaz K, Raja A. Various patterns of extraction in patients with crowding. Pakistan Orthod J. 2017;9(2):106-13.
18. Vignesh T, Kumar KS, Tamizharasi SK. Mandibular incisor extraction in orthodontics: A systematic review. J Indian Acad Dent Spec Res. 2014;1(1):1-5.
19. Zhylich D, Suri S. Mandibular incisor extraction: a systematic review of an uncommon extraction choice in orthodontic treatment. J Orthod. 2011;38(3):185-95.
20. Thilander B, Pena L, Infante C, Parada SS, de Mayorga C. Prevalence of malocclusion and orthodontic treatment need in children and adolescents in Bogota, Colombia. An epidemiological study related to different stages of dental development. EurJ Orthod. 2001;23(2):153-68.
21. Youssef J, Skaf Z. Missing or extraction of a mandibular incisor in orthodontics. J Dent Health Oral Disord Ther. 2015;2(5):00066.

22. Janson G, Maria FR, Bombonatti R. Frequency evaluation of different extraction protocols in orthodontic treatment during 35 years. Prog Orthod 2014;15(1):1-7.
23. Kokich Jr VO. Treatment of a Class I malocclusion with a carious mandibular incisor and no Bolton discrepancy. Am J Orthod Dentofacial Orthop. 2000;118(1):107-13.