



Original Article

Tooth Dimensions, Arch Width, and Treatment Outcomes after Mandibular Incisor Extraction

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Main Points

- Mandibular incisor extraction treatment was associated with reductions in mandibular intercanine width and Bolton ratios.
- Overbite decreased significantly after treatment.
- Careful assessment of Bolton ratios and coordination of maxillary and mandibular arch dimensions may help optimize the final occlusal relationship in patients treated with mandibular incisor extraction.

ABSTRACT

Objective: To evaluate treatment-related changes in tooth widths, ratios, and dental arch changes in patients treated with mandibular incisor extraction treatment (MIET).

Methods: Pre- (T1) and post-treatment (T2) digital dental casts of 24 patients (13 female, 11 male; mean age: 16.58±3.81 years) who underwent MIET were examined. Mesiodistal tooth widths, transverse dental arch widths, overjet, and overbite were measured, and the Bolton ratios were calculated using OrthoCAD software. Pre- and post-treatment values were compared. Correlations between post-treatment overjet and related parameters were analyzed.

Results: Mesiodistal widths of the maxillary incisors decreased from T1 to T2, with a statistically significant decrease in the upper right lateral (-0.18±0.32 mm, p=0.010) and upper left central incisors (-0.20±0.36 mm, p=0.011). Mandibular intercanine width decreased (-2.56±3.39 mm; p<0.001), whereas maxillary and mandibular interpremolar width (2.91±2.06 mm, p<0.001; 1.57±2.68 mm, p=0.008) and mandibular intermolar width (1.09±1.94 mm, p=0.013) increased significantly. Overbite (-1.00±1.52 mm, p=0.004), the anterior Bolton ratio (-10.51±2.40%, p<0.001), and the overall Bolton ratio (-4.89±1.83, p<0.001) decreased during treatment. Post-treatment overjet was negatively correlated with the pre-treatment anterior and overall Bolton ratios and positively correlated with the pre-treatment arch length, the difference in intercanine width (T2-T1), and the pre-treatment overbite.

Conclusion: MIET caused a decrease in mandibular intercanine width and the anterior Bolton ratio, despite the interproximal reduction performed on the upper incisors. Given the potential consequences of these results on anterior and canine guidance, greater interproximal reduction in the maxilla and close attention to the torque and final positions of the mandibular canines may be recommended.

Keywords: Lower incisor extraction, digital orthodontic model, tooth size, arch width

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INTRODUCTION

Since the idea of gaining space through extractions in orthodontic treatment emerged, various extraction sequences have been performed and their results have been reported in the literature. Among these methods, mandibular incisor extraction treatment (MIET) was first introduced by Hahn¹ in 1942, and has been established as a treatment option for lower anterior crowding cases, one of the most common reasons for seeking orthodontic treatment.^{2,3} It is particularly indicated in patients with an Angle Class I molar relationship, severe lower anterior crowding, and a Bolton discrepancy, or in cases with an edge-to-edge incisor relationship that show a tendency toward an anterior crossbite or an anterior open bite.³⁻⁷

The potential advantages of MIET include limited changes in the positions of remaining teeth and, consequently, more stable long-term results; a quick solution for lower anterior dental crowding requiring less effort; and fewer changes in the facial profile compared with premolar extraction protocols.⁸⁻¹² Although MIET was more frequently performed in the past, its use has declined over time and has been reported to be included in only 1-6% of orthodontic treatment plans.^{6,13} This may be attributed to undesirable outcomes of MIET, such as increased overjet, mesialization of the lower canines, disruption of canine guidance during lateral movements, and esthetic and functional concerns associated with the absence of a mandibular incisor.

Kokich and Shapiro⁹ emphasized the importance of performing a careful diagnostic setup before deciding to extract a mandibular incisor. In such cases, Bolton's tooth-size analysis¹⁴ guides onrthodontists in detecting dimensional discrepancies between maxillary and mandibular teeth and helps to determine which tooth should be extracted to achieve the ideal treatment outcome or which changes in tooth position can prevent undesirable outcomes. Several strategies have been proposed to optimize occlusal relationships after mandibular incisor extraction. These include palatal crown torque of the maxillary canines and buccal crown torque with distal angulation of the mandibular canines to establish appropriate canine guidance. Interproximal reduction (IPR) of the maxillary incisors has also been recommended to control increases in overjet. When IPR is limited by tooth morphology, compensatory changes in incisor angulations, such as buccal inclination of the mandibular incisors and palatal inclination of the maxillary incisors, may be considered.^{7,9,15,16}

Despite its potential advantages, MIET may result in unfavorable changes in dental arch and occlusal relationships. Therefore, careful case selection and appropriate compensatory adjustments are essential to minimize these effects while addressing patient expectations and functional requirements. Previous studies on MIET have mostly consisted of case reports, papers addressing esthetic concerns, and reviews evaluating current scientific opinions. To date, no studies have investigated changes in dental arch and tooth dimensions on digital dental casts before and after lower incisor extraction.

Therefore, the aim of this study was to evaluate changes in digital dental models before (T1) and after (T2) orthodontic treatment with mandibular incisor extraction. Specifically changes in mesiodistal (MD) tooth dimensions, transverse dental arch widths, Bolton ratios, overjet, and overbite were assessed, together with the relationships between post-treatment overjet and relevant dental parameters. The hypothesis (H1) of the study was that mandibular incisor extraction treatment would lead to significant changes in dental and arch parameters between T1 and T2, and that significant correlations would exist between post-treatment overjet and the evaluated dental variables.

METHODS

Ethical approval for this retrospective study was obtained from the Gazi University Ethical Committee (approval no: 2022-179, date: 08.02.2022). The study used pre- and post-treatment digital dental models of patients who underwent MIET at the Department of Orthodontics, Gazi University Faculty of Dentistry between 2010 and 2023. Patients with complete pre- and post-treatment records who had no restorations on the contact surfaces of their teeth before or during orthodontic treatment were included; this absence was confirmed by their pre- and post-treatment panoramic radiographs. Patients were excluded if they had undergone previous orthodontic treatment; had teeth other than mandibular incisors or third molars extracted before or during treatment; or had systemic diseases or craniofacial syndromes that could affect tooth or dental arch dimensions. Since the study was retrospective and based on existing orthodontic records, written informed consent for the use of anonymized records was obtained from the patients and/or their legal guardians at the beginning of treatment.

Patients were treated by orthodontic residents under the supervision of faculty members. All patients were treated with Roth-prescription fixed appliances with 0.018-inch slots. All teeth, including the second molars, were bonded, and similar archwire sequences were used throughout treatment. Debonding was performed after a 2-month stabilization period using a 0.017x0.025-inch stainless-steel archwire. Patients who required additional extractions during treatment or whose records could confound the measurements were excluded.

Because this study relied on measurements made on digital dental models, patient records with dental casts fulfilling the following criteria were included for further evaluation:

- Presence of high-quality pre- and post-treatment plaster models with intact structural integrity;
- Complete dentition, except for third molars and the extracted mandibular incisor in the post-treatment model, with all teeth fully erupted and crown dimensions clearly measurable;

- Absence of fractures, air bubbles, or excess plaster particles on the tooth surfaces that could affect size measurements.

The final study group comprised the pre- and post-treatment dental casts of 24 patients (13 female, 11 male; mean chronological age: 16.58 ± 3.81 years) treated with MIET. The plaster models were scanned using an intraoral scanner (iTero Element 2, Align Technology, San Jose, CA, USA), converted into a digital format, and imported into model analysis software (OrthoCAD software version 4.5, Align Technology, San Jose, CA, USA). The landmarking procedure was standardized prior to measurement as follows: anatomical landmarks were manually identified by a single examiner (BAA), and the corresponding linear measurements and Bolton calculations (described below) were automatically generated by the software.

Mesiodistal tooth widths: For the incisors and canines, mesiodistal width was measured as the greatest distance between the mesial and distal aspects of the crown. For the premolars and first molars, MD width was measured between the most mesial and distal contact points in the occlusal view (Figure 1). Mandibular incisors were excluded from the tooth-width comparison because the extraction of a single mandibular incisor resulted in non-uniform, insufficient tooth-specific sample sizes.

Transverse dental arch widths: Intercanine, interpremolar, and intermolar widths were measured as the distances between the cusp tips of the right and left canines; the buccal cusp tips of the first premolars; and the mesiobuccal cusp tips of the right and left first molars were recorded as intercanine, interpremolar and intermolar widths, respectively (Figure 2).

Overjet: Overjet was measured as the sagittal distance between the most prominent maxillary and mandibular incisors (Figure 3).

Overbite: The vertical distance between the incisal edges of the most prominent maxillary and mandibular incisors was recorded as overbite (Figure 3).

The following additional parameters obtained from the model analysis software were also utilized in this study:

Required arch length: Calculated as the sum of the MD widths of the incisors, canines, and premolars.

Available arch length: Measured as the distance from the mesial surface of the first molar to the canine, and from the canine to the midline of the incisors, with the right and left values summed.

Space analysis: Calculated by subtracting the required arch length from the available arch length.

Anterior Bolton ratio: Defined as the sum of the MD widths of the mandibular anterior teeth (canine-to-canine) divided by that of the maxillary anterior teeth, multiplied by 100.

Overall Bolton ratio: Defined as the sum of the MD widths of the mandibular teeth divided by that of the maxillary teeth, excluding the second and third molars, multiplied by 100.

Statistical Analysis

The required sample size was determined using a power analysis based on the study by Germec-Cakan et al.¹⁷ To achieve 80% statistical power with a significance level of $\alpha=0.05$, a minimum of 19 patients was required. Consequently, 24 patients meeting the inclusion criteria were enrolled in the study, thereby exceeding the required sample size.

To assess intra-examiner reliability, the same researcher repeated all measurements on the complete dataset one month after the initial measurements. Values ranged from 0.663 to 0.993, indicating moderate to excellent intra-examiner reliability according to the interpretation criteria proposed by Koo and Li.¹⁸ Pre- and post-treatment measurements were compared to evaluate treatment-related changes in tooth dimensions, transverse dental arch widths, space parameters, Bolton ratios, overjet, and overbite. Correlation analyses were performed specifically to investigate the relationships between

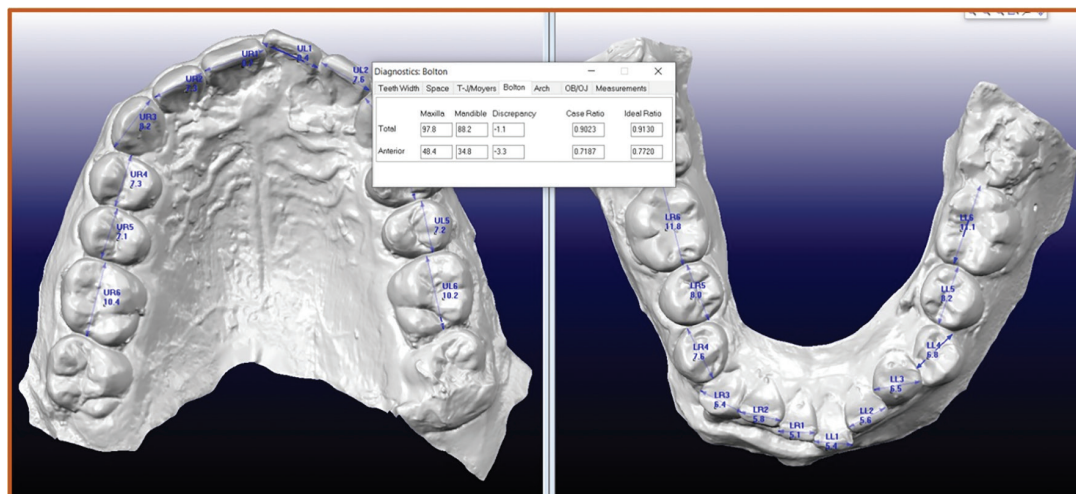


Figure 1. Determination of tooth widths and Bolton's ratios on digital dental models.

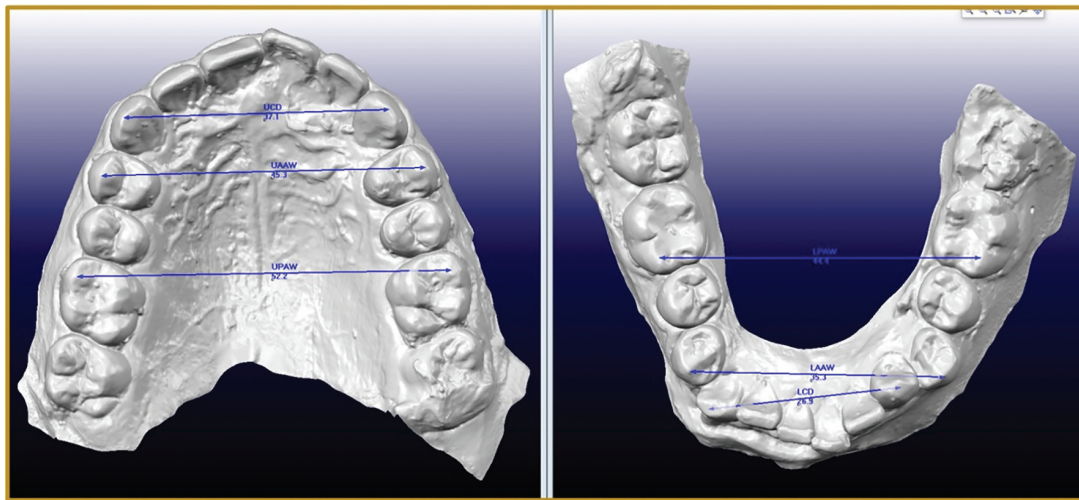


Figure 2. Arch width analysis on digital dental models.

post-treatment overjet and the evaluated dental and arch parameters, given the clinical relevance of increased overjet as a potential consequence of MIET.

Descriptive statistics were presented as mean $\pm$ standard deviation for continuous variables and median (minimum-maximum) values. The distribution of the data was assessed before selecting the appropriate statistical analysis. To compare pre- and post-treatment changes in maxillary and mandibular teeth and arch widths, and in overjet and overbite values, paired t-tests were used for normally distributed data, while Wilcoxon signed-rank tests were applied for non-normally distributed data. Correlations between overjet, overbite, and arch widths and pre- and post-treatment changes were assessed using Pearson correlation coefficients for normally distributed data and Spearman correlation coefficients for non-normally distributed data. Statistical significance was set as $p < 0.05$. All statistical analyses were performed using SPSS for Windows (version 11.5; SPSS Inc., Chicago, IL, USA).

RESULTS

Evaluation of Pretreatment Models (T1)

The study group comprised 24 patients (13 female, 11 male) with a mean age of 16.58 ± 3.81 years. At pre-treatment (T1), the mean maxillary and mandibular crowding values were -2.38 ± 2.46 mm and -5.60 ± 1.29 mm, respectively. The mean pre-treatment overjet was 3.19 ± 1.73 mm, and the mean pre-treatment overbite was 3.02 ± 1.89 mm. The pre-treatment anterior and overall Bolton ratios were $79.07 \pm 3.13\%$ and $92.14 \pm 2.16\%$, respectively.

Regarding the distribution of extracted mandibular incisors, the mandibular right central incisor was extracted in 4 patients, the right lateral incisor in 1, the left central incisor in 14, and the left lateral incisor in 5 patients.

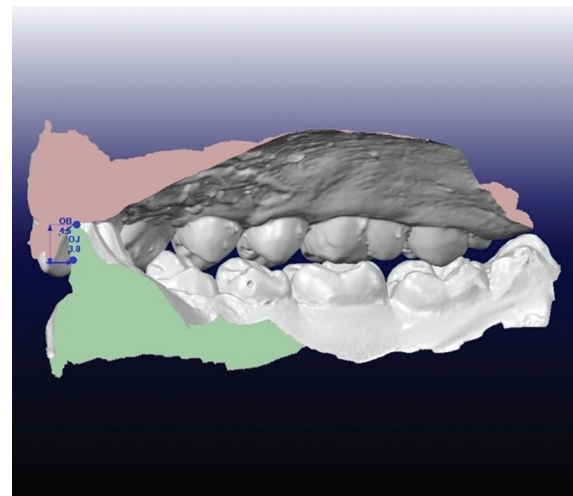


Figure 3. Overjet and overbite analysis on digital dental models.

Treatment-Related Changes (T2-T1)

The MD width of the maxillary incisors decreased from T1 to T2; however, the reductions were statistically significant only for the maxillary right lateral incisor (-0.18 ± 0.31 , $p = 0.010$) and left central incisor (-0.20 ± 0.35 , $p = 0.011$) (Table 1). Regarding the mandibular teeth, the incisors could not be evaluated due to an insufficient sample size resulting from the extractions. However, a significant decrease in the MD dimensions of left canine (-0.17 ± 0.31 , $p = 0.012$), right canine (-0.15 ± 0.47 , $p = 0.032$), and left first premolar (-0.16 ± 0.28 , $p = 0.010$) was observed (Table 1). As an expected consequence of the treatment modality, the Bolton anterior (-10.51 ± 2.40 , $p < 0.001$) and overall (-4.89 ± 1.83 , $p < 0.001$) ratios significantly decreased during treatment (Table 2).

Regarding transversal maxillary arch dimensions, intercanine and intermolar widths showed small, non-significant increases of 0.49 ± 1.79 mm ($p = 0.193$) and 0.62 ± 1.86 mm ($p = 0.117$), respectively. In contrast, maxillary interpremolar width increased significantly by 2.90 ± 2.06 mm ($p < 0.001$).

Conversely, intercanine width in mandible showed a significant decrease (-2.55 ± 3.39 , $p < 0.001$), while the interpremolar and intermolar widths increased significantly (1.57 ± 2.68 , $p = 0.008$; 1.09 ± 1.93 , $p = 0.013$, respectively) (Table 3).

Overjet and overbite decreased during treatment, but only the change in overbite was statistically significant (-0.99 ± 1.51 , $p = 0.004$) (Table 4).

Correlations Related to Achieved Post-Treatment Overjet

The Bolton anterior ratio at T1 ($r = -0.522$, $p = 0.009$) and at T2 ($r = -0.670$, $p < 0.001$), and the overall ratio at T2 ($r = -0.657$, $p < 0.001$), were strongly negatively correlated with overjet at T2.

A positive correlation was found between the sum of MD width of all maxillary (6-6) teeth ($r = -0.453$, $p = 0.026$), anterior maxillary (3-3) teeth ($r = -0.494$, $p = 0.014$) at T2 and post-treatment overjet.

On the other hand, the maxillary interpremolar width at T1 was positively correlated with overjet at T2 ($r = 0.437$, $p = 0.033$). A positive correlation was also detected between the change in mandibular intercanine width (T2-T1) and post-treatment overjet ($r = 0.464$, $p = 0.022$).

Furthermore, overbite at T1 ($r = 0.447$, $p = 0.029$) and at T2 ($r = 0.517$, $p = 0.010$) were positively correlated with overjet at T2.

Table 1. Pre- and post-treatment changes in widths of maxillary teeth (mm)

Tooth number	Pre-treatment	Post-treatment	Difference	p
11	8.72±0.45	8.57±0.49	-0.15±0.38	0.072
12	6.76±0.44	6.58±0.46	-0.18±0.31	0.010
13	7.94±0.30	7.84±0.43	-0.10±0.36	0.192
14	7.16±0.46	7.14±0.49	-0.02±0.26	0.702
15	7.04±0.33	7.08±0.35	0.04±0.19	0.176
16	10.75±0.41	10.71±0.43	-0.03±0.42	0.669
21	8.69±0.47	8.49±0.50	-0.20±0.35	0.011
22	6.63±0.44	6.52±0.39	-0.10±0.32	0.112
23	7.77±0.36	7.81±0.49	0.04±0.31	0.523
24	7.10±0.38	7.00±0.46	-0.10±0.39	0.166
25	7.01±0.37	6.93±0.37	-0.07±0.34	0.276
26	10.71±0.40	10.58±0.43	-0.12±0.34	0.088

Statistical significance was set at $p < 0.05$, values are presented as mean $\pm$ standard deviation. All measurements were calculated from the complete sample of 24 patients.

Table 2. Pre- and post-treatment changes in Bolton's ratios

Bolton's ratio	Pre-treatment	Post-treatment	Difference	p
Anterior ratio (%)	79.07±3.13	68.56±2.84	-10.51±2.40	<0.001
Total ratio (%)	92.14±2.16	87.25±2.01	-4.89±1.83	<0.001

Statistical significance was set at $p < 0.05$.

Table 3. Pre- and post-treatment changes in maxillary and mandibular arch widths

		Pre-treatment	Post-treatment	Difference	p
Maxilla	Intercanine	34.49±1.97	34.98±1.49	0.49±1.79	0.193
	Interpremolar	40.67±2.35	43.58±1.55	2.90±2.06	<0.001
	Intermolar	50.30±2.12	50.92±1.55	0.62±1.86	0.117
Mandible	Intercanine	25.31±1.78	22.75±3.27	-2.55±3.39	<0.001
	Interpremolar	31.86±2.93	33.44±1.19	1.57±2.68	0.008
	Intermolar	42.42±2.26	43.51±1.32	1.09±1.93	0.013

Statistical significance was set at $p < 0.05$.

Table 4. Pre- and post-treatment changes in overjet and overbite

	Pre-treatment	Post-treatment	Difference	p
Overjet	3.19±1.73	2.85±1.15	-0.34±1.99	0.951
Overbite	3.02±1.89	2.02±1.13	-0.99±1.51	0.004

Statistical significance was set at $p < 0.05$.

DISCUSSION

Mandibular incisor extraction treatment offers successful and stable outcomes when performed with appropriate indications and treatment planning.^{6,10} However, extraction of a single lower anterior tooth may lead to undesirable occlusal and periodontal consequences, including compromised canine guidance, development of open gingival embrasures, and reopening of the extraction space. These issues can leave aesthetic and periodontal sequelae after the treatment is completed.^{4,12,19} A better understanding of the dental and arch changes associated with MIET may therefore facilitate appropriate case selection and help to minimize unfavorable treatment outcomes. Being aware of potential challenges encountered during treatment and taking precautions at the outset can give clinicians greater confidence and facilitate addressing patients' concerns regarding extractions in the aesthetic zone. Based on this rationale, the present study aimed to determine the dental arch changes in patients treated with MIET using digital dental models and to explain interrelated parameters. The findings partially supported the study hypothesis, demonstrating significant treatment related changes in several dental and arch parameters, as well as significant correlations between post-treatment overjet and selected dental variables.

The present study was based on measurements obtained from digital dental models. Previous studies have reported that digital orthodontic models provide clinically acceptable accuracy and reliability for tooth-width, Bolton ratio, and dental arch measurements compared to conventional plaster models.²⁰⁻²³ Additionally, the intraoral scanner and OrthoCAD system have been shown to provide clinically acceptable accuracy, reliability, and reproducibility for measuring tooth widths and calculating Bolton ratios.²⁴ Therefore, the use of digital models and OrthoCAD software in this study can be considered appropriate for the evaluated linear measurements.

An increase in overjet is one of the most common outcomes of MIET, as extensively documented in the literature.^{4,8,9,16} Interproximal reduction of the maxillary incisors has been recommended as one strategy to compensate for the tooth-size discrepancy created by mandibular incisor extraction and to limit an increase in overjet.^{9,15} In the present study, the MD widths of the teeth were measured at T1 and T2, revealing a decrease in the MD widths of the maxillary incisors. This finding demonstrates that the literature-based recommendation was implemented; this implementation may also explain the observed decrease in overjet at T2. For IPR applications, teeth with a triangular structure and high enamel thickness-particularly those that widen toward the incisal edge-are recommended.¹⁶ However, IPR may be limited by individual tooth morphology and enamel thickness. In such cases, compensatory changes in incisor inclination have been suggested as an alternative strategy for controlling the tendency toward increased overjet following mandibular incisor extraction.^{9,16} The decrease in overbite observed at the

end of treatment may reflect treatment-related dentoalveolar changes; however, since cephalometric evaluation was not performed, these changes could not be examined radiographically, which represents a limitation of our study.

Dacre²⁵ reported a reduction in mandibular intercanine width during MIET, as the mandibular anterior teeth were aligned. A similar pattern was observed in the present study, however, no significant change was observed in the maxillary intercanine distance. In contrast, maxillary interpremolar width and mandibular interpremolar and intermolar widths increased significantly from T1 to T2. While some studies have suggested that MIET can contribute to long-term stability by preserving arch form,^{17,26,27} the transverse changes observed in the present sample indicate that arch form was not completely preserved during treatment. Given that preformed archwires are shaped according to the standard symmetrical incisor number, it is critical to pay attention to arch forms during lower incisor extraction treatment. However, the dimensions and shapes of the archwires used were not directly assessed in this retrospective study; therefore, their contribution to the observed transverse changes remains speculative.

Bolton's tooth size discrepancy analysis serves as a guide for orthodontists in correctly identifying indications for MIET and selecting the appropriate incisor for extraction.¹⁴ Ileri et al.⁸ stated that cases with a Bolton anterior ratio of $81.7 \pm 4.5\%$ were suitable for MIET. In the present study, the anterior ratio was $79.07 \pm 3.13\%$, which is consistent with this finding. However, it must be emphasized that a Bolton analysis performed following mandibular incisor extraction cannot be interpreted in the same manner as a conventional Bolton analysis performed on a complete mandibular anterior dentition; the extraction itself inevitably reduces the total MD width of the mandibular anterior segment. Therefore, post-treatment Bolton ratios in the present study were considered descriptive parameters reflecting the magnitude of treatment-related interarch tooth-size alterations rather than stand-alone indicators of ideal tooth-size harmony. When considered together with overjet, overbite, and the amount of maxillary interproximal reduction, these values can still provide clinically relevant information for evaluating the final anterior occlusal relationship after MIET.

Furthermore, at T1, the anterior ratio ($r = -0.522$) and the overall ratio ($r = -0.657$) were both negatively correlated with the post-treatment overjet value. These findings demonstrated two major insights regarding our cohort: the indication for lower incisor extraction was correct, but nearly all the space gained from the extraction was consumed to eliminate the lower anterior crowding (-5.60 ± 1.29 mm). Consequently, minimal space remained for incisor retraction, which could have increased the overjet. These results indicate that the posterior Bolton discrepancy was not entirely eliminated, suggesting that additional space for IPR on the posterior teeth may be required if enamel thickness permits. However, because a severe skeletal discrepancy is a contraindication for MIET and

acceptable posterior settling is assumed at the beginning of treatment, maintenance of the posterior Bolton discrepancy might have helped the management of the overjet.

Since an increase in overjet is a frequently reported consequence of MIET and can be associated with critical clinical outcomes such as the loss of anterior guidance, the parameters related to post-treatment overjet were investigated. Maxillary interpremolar width at T1 ($r=0.437$) and mandibular intercanine width difference (T2-T1) ($r=0.464$) were positively correlated with post-treatment overjet at T2. These findings provide an important clinical recommendation for practitioners: pretreatment maxillary arch widths should be preserved or reduced, coordinated with the mandibular intercanine width whenever possible; preformed archwires must be utilized with caution to eliminate this possible outcome.

Study Limitations

This study has several limitations. The primary limitation is its retrospective design. To minimize the potential negative effects, the clinical procedures performed on the patients were evaluated in detail, and any confounding factors that could compromise the methodology were excluded. Second, the study was based exclusively on dental model measurements, and cephalometric changes were not evaluated. Therefore, the potential contributions of incisor inclination, anteroposterior tooth movement, and other dentoalveolar changes to the observed overjet and overbite outcomes could not be determined. Finally, although the sample size exceeded the minimum number required by the power analysis, the relatively small size remains a limitation, particularly for the secondary correlation analyses. Future studies with larger samples and comparable power calculations may provide reliable evidence regarding the clinical associations observed in mandibular incisor extraction cases.

CONCLUSION

Following MIET, mesiodistal widths of the maxillary incisors decreased. A significant decrease was also observed in both anterior and overall Bolton ratios. Overbite and overjet decreased during treatment, with the change in overbite being statistically significant. Maxillary interpremolar and mandibular interpremolar and intermolar widths increased significantly, whereas mandibular intercanine width decreased.

Ethics

Ethics Committee Approval: Ethical approval for this retrospective study was obtained from the Gazi University Ethical Committee (approval no: 2022-179, date: 08.02.2022).

Informed Consent: Since the study was retrospective and based on existing orthodontic records, written informed consent for the use of anonymized records was obtained from the patients and/or their legal guardians at the beginning of treatment.

Footnotes

Author Contributions: Concept - B.A.A., B.B.T., N.C.B.; Design - B.A.A., B.B.T., N.C.B.; Analysis and/or Interpretation - B.A.A., İ.K., N.C.B.; Literature Search - B.A.A., N.C.B.; Writing - N.C.B.

Conflict of Interest: No conflict of interest was declared by the authors.

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REFERENCES

1. Hahn GW. Problems in the treatment of malocclusion. *Angle Orthod.* 1942;12(2):61-82. [\[CrossRef\]](#)
2. Patano A, Malcangi G, Inchingolo AD, et al. Mandibular crowding: diagnosis and management-a scoping review. *J Pers Med.* 2023;13(5):774. [\[CrossRef\]](#)
3. Bahreman A-A. Lower incisor extraction in orthodontic treatment. *Am J Orthod Dentofacial Orthop.* 1977;72(5):560-567. [\[CrossRef\]](#)
4. Canut J-A. Mandibular incisor extraction: indications and long-term evaluation. *Eur J Orthod.* 1996;18(5):485-489. [\[CrossRef\]](#)
5. Raju DS, Veereshi A, Naidu DL, Raju B, Goel M, Maheshwari A. Therapeutic extraction of lower incisor for orthodontic treatment. *J Contemp Dent Pract.* 2012;13(4):574-577. [\[CrossRef\]](#)
6. Zhylich D, Suri S. Mandibular incisor extraction: a systematic review of an uncommon extraction choice in orthodontic treatment. *J Orthod.* 2011;38(3):185-195. [\[CrossRef\]](#)
7. Matsumoto MAN, Romano FL, Ferreira JTL, Tanaka S, Morizono EN. Lower incisor extraction: an orthodontic treatment option. *Dental Press J Orthod.* 2010;15(6):143-161. [\[CrossRef\]](#)
8. İleri Z, Başçiftci FA, Malkoc S, Ramoglu SI. Comparison of the outcomes of the lower incisor extraction, premolar extraction and non-extraction treatments. *Eur J Orthod.* 2012;34(6):681-685. [\[CrossRef\]](#)
9. Kokich VG, Shapiro PA. Lower incisor extraction in orthodontic treatment. Four clinical reports. *Angle Orthod.* 1984;54(2):139-153. [\[CrossRef\]](#)
10. Rosenstein SW. A lower incisor extraction? *Aust Orthod J.* 1976;4(3):107-109. [\[CrossRef\]](#)
11. Klein DJ. The mandibular central incisor, an extraction option. *Am J Orthod Dentofacial Orthop.* 1997;111(3):253-259. [\[CrossRef\]](#)
12. Uribe F, Holliday B, Nanda R. Incidence of open gingival embrasures after mandibular incisor extractions: a clinical photographic evaluation. *Am J Orthod Dentofacial Orthop.* 2011;139(1):49-54. [\[CrossRef\]](#)
13. Proffit WR. Forty-year review of extraction frequencies at a university orthodontic clinic. *Angle Orthod.* 1994;64(6):407-414. [\[CrossRef\]](#)
14. Bolton WA. Disharmony in tooth size and its relation to the analysis and treatment of malocclusion. *Angle Orthod.* 1958;28(3):113-130. [\[CrossRef\]](#)
15. Kokich VO Jr. Treatment of a class I malocclusion with a carious mandibular incisor and no Bolton discrepancy. *Am J Orthod Dentofacial Orthop.* 2000;118(1):107-113. [\[CrossRef\]](#)
16. Faerovig E, Zachrisson BU. Effects of mandibular incisor extraction on anterior occlusion in adults with class III malocclusion and reduced overbite. *Am J Orthod Dentofacial Orthop.* 1999;115(2):113-124. [\[CrossRef\]](#)
17. Germec-Cakan D, Taner TU, Akan S. Arch-width and perimeter changes in patients with borderline class I malocclusion treated with extractions or without extractions with air-rotor stripping. *Am J Orthod Dentofacial Orthop.* 2010;137(6):734.e1-e7; discussion 734-735. [\[CrossRef\]](#)

18. Koo TK, Li MY. A Guideline of selecting and reporting intraclass correlation coefficients for reliability research. *J Chiropr Med.* 2016;15(2):155-163. Erratum in: *J Chiropr Med.* 2017;16(4):346. [\[CrossRef\]](#)
19. Pithon MM, Santos AM, Couto FS, de Freitas LMA, da Silva Coqueiro R. Comparative evaluation of esthetic perception of black spaces in patients with mandibular incisor extraction. *Angle Orthod.* 2012;82(5):806-811. [\[CrossRef\]](#)
20. Rossini G, Parrini S, Castroflorio T, Deregibus A, Debernardi CL. Diagnostic accuracy and measurement sensitivity of digital models for orthodontic purposes: a systematic review. *Am J Orthod Dentofacial Orthop.* 2016;149(2):161-170. [\[CrossRef\]](#)
21. Tunca M, Tunca Y, Kotan S, Bilen S. Comparison of linear measurements and Bolton analysis on the model obtained from conventional method with OrthoCAD software. *Van Dış Hekimliği Dergisi.* 2021;2(2):1-10. [\[CrossRef\]](#)
22. Jaber ST, Hajeer MY, Alkhouli KW, et al. Evaluation of three-dimensional digital models formulated from direct intra-oral scanning of dental arches in comparison with extra-oral scanning of poured dental models in terms of dimensional accuracy and reliability. *Cureus.* 2024;16(2):e54869. [\[CrossRef\]](#)
23. Kusaibati AM, Sultan K, Hajeer MY, Gkantidis N. Digital setup accuracy for moderate crowding correction with fixed orthodontic appliances: a prospective study. *Prog in Orthod.* 2024;25(1):13. [\[CrossRef\]](#)
24. Naidu D, Freer TJ. Validity, reliability, and reproducibility of the iOC intraoral scanner: a comparison of tooth widths and Bolton ratios. *Am J Orthod Dentofacial Orthop.* 2013;144(2):304-310. [\[CrossRef\]](#)
25. Dacre JT. The long term effects of one lower incisor extraction. *Eur J Orthod.* 1985;7(2):136-144. [\[CrossRef\]](#)
26. Riedel RA, Little RM, Bui TD. Mandibular incisor extraction--postretention evaluation of stability and relapse. *Angle Orthod.* 1992;62(2):103-116. [\[CrossRef\]](#)
27. Bayram M, Ozer M. Mandibular incisor extraction treatment of a class I malocclusion with bolton discrepancy: a case report. *Eur J Dent.* 2007;1(1):54-59. [\[CrossRef\]](#)