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Comparison of Automatic and Manual Digital Bolton Analyses: Accuracy of Clear Aligner Design Software

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Research Article

History

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ABSTRACT

Objectives: This study compared the accuracy of automated and manual measurements on digital model Bolton analyses performed using two clear aligner therapy (CAT) planning software programs.
Materials and Methods: Digital intraoral scans of 40 patients undergoing CAT were analyzed. Mesiodistal tooth widths and Bolton ratios were measured using (1) the manual digital (MD) method via OrthoViewer software, (2) the ClinCheck system, and (3) DentOne software employing AI-based segmentation. The anterior and total Bolton values, as well as individual tooth width measurements, were statistically compared using nonparametric tests. The Kruskal–Wallis test was performed to compare differences, and the Mann–Whitney U test was used for post-hoc comparisons between groups. Measurement reliability was assessed using intra- and interobserver intraclass correlation coefficients (ICCs).
Results: No significant differences were observed in the anterior Bolton ratios across groups ($p > 0.05$), whereas the total Bolton values showed significant differences between software and MD measurements ($p < 0.05$). ClinCheck showed smaller deviations from manual measurements than DentOne, particularly for maxillary molars and incisors. The largest discrepancies were observed in the posterior region. For teeth 26 and 16, the average deviations from the MD method were 0.56 mm and 0.47 mm for ClinCheck and 0.84 mm and 0.87 mm for DentOne, respectively.
Conclusions: While the automated Bolton analyses performed by ClinCheck and DentOne are clinically acceptable, their measurements differ significantly from MD methods. These discrepancies are more pronounced in posterior teeth, likely due to anatomical complexity and limitations in intraoral scanning. Clinicians should perform intraoral scans carefully and consider manual verification when interpreting automated Bolton results, particularly for molars and crowded segments.

Keywords: Artificial intelligence, automated measurement, bolton analysis, digital models, orthodontic treatment, software

Otomatik ve Manuel Dijital Bolton Analizlerinin Karşılaştırılması: Şeffaf Plak Tasarım Yazılımlarının Ölçüm Doğruluğu

Araştırma Makalesi

Süreç

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ÖZ

Amaç: Bu çalışmanın amacı, iki şeffaf plak tedavisi (ŞPT) planlama yazılımında dijital modeller üzerinde gerçekleştirilen Bolton analizlerinde otomatik ve manuel ölçümlerin doğruluğunu karşılaştırmaktır.
Gereç ve Yöntemler: ŞPT uygulanan 40 hastaya ait dijital ağız içi taramaları analiz edilmiştir. Dişlerin meziodistal genişlikleri ve Bolton oranları; (1) OrthoViewer yazılımı kullanılarak manuel dijital (MD) yöntemle, yapay zekâ tabanlı segmentasyon yöntemini kullanan (2) ClinCheck sistemi ve (3) DentOne yazılımlarıyla ölçülmüştür. Anterior ve total Bolton değerleri ile dişlerin genişlikleri nonparametrik testlerle karşılaştırılmıştır. Gruplar arası farklılıklar Kruskal–Wallis testi, post-hoc ikili karşılaştırmalar ise Mann–Whitney U testi ile değerlendirilmiştir. Ölçümlerin güvenilirliğinin değerlendirilmesinde gözlemci içi ve gözlemciler arası uyum, sınıf içi korelasyon katsayısı (ICC) ile belirlenmiştir.
Bulgular: Gruplar arasında anterior Bolton oranlarında anlamlı fark saptanmazken ($p > 0,05$), total Bolton değerlerinde yazılımlar ile MD ölçümleri arasında anlamlı farklılıklar bulunmuştur ($p < 0,05$). ClinCheck, özellikle maksiller molar ve kesici bölgelerinde, DentOne'a kıyasla manuel ölçümlere daha yakın sonuçlar göstermiştir. En belirgin uyumsuzluk posterior bölgede gözlenmiştir. 26 ve 16 numaralı dişlerde MD yönteme göre ortalama sapmalar ClinCheck için sırasıyla 0,56 mm ve 0,47 mm; DentOne için 0,84 mm ve 0,87 mm olarak belirlenmiştir.
Sonuçlar: ClinCheck ve DentOne yazılımlarının otomatik Bolton analizleri klinik olarak kabul edilebilir düzeydedir; ancak ölçümler MD yöntemiyle anlamlı şekilde farklılık göstermektedir. Bu farklılıklar, anatomik karmaşıklık ve ağız içi taramanın sınırlılıkları nedeniyle özellikle posterior dişlerde daha belirgindir. Klinik uygulamalarda intraoral taramaların dikkatli yapılması ve otomatik Bolton sonuçlarının değerlendirilmesinde, özellikle molar dişlerde ve çapraşık bölgelerde, manuel doğrulamanın göz önünde bulundurulması önerilmektedir.

Anahtar Kelimeler: Bolton analizi, dijital modeller, Ortodontik tedavi, otomatik ölçüm, yapay zekâ, yazılım

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Introduction

Accurate assessment of tooth dimensions and their proportional relationships is crucial for orthodontic diagnosis and treatment planning, as it directly affects both functional and aesthetic outcomes. Bolton analysis is a widely used method for assessing mesiodistal width discrepancies between the maxillary and mandibular teeth.[1] When deviations from the ideal Bolton ratio exceed clinically acceptable thresholds, achieving optimal esthetics and occlusion may necessitate modifications to mesiodistal tooth dimensions. These modifications can be achieved through restorative and prosthetic interventions to increase tooth width or through interproximal reduction (IPR) and extractions to reduce it.[2-4] The accuracy of the measurement method is essential for determining the precise amount of tooth structure that should be adjusted to optimize treatment outcomes.

Various methods are used to measure mesiodistal tooth widths and perform Bolton analysis.[5] The conventional approach involves measuring tooth widths on physical models made from plaster or three-dimensional (3D) printing.[6] However, manual methods are time-consuming and require storage for physical models. Additionally, their accuracy depends on clinician experience and the precision of measuring instruments, making them prone to operator-dependent errors.[7,8] Intraoral scanning systems allow teeth and adjacent structures to be digitized into 3D models. In the manual measurement method performed on 3D digital models, researchers import digital scans into specialized software, identify the mesial and distal points of the teeth, and obtain precise tooth width measurements. The ability to examine the dental model in detail in three dimensions using software tools, along with the elimination of measurement instrument errors, facilitates standardization, reduces processing time, and simplifies record storage.[9,10]

Clear aligner therapy (CAT) planning software performs tooth segmentation, arch length analysis, tooth width measurements, and Bolton discrepancy evaluations before generating a treatment plan.[11,12] Automated Bolton analysis and tooth width calculation methods offer an alternative to manual techniques by reducing operator-dependent variability and improving measurement consistency. However, few studies have evaluated the accuracy and reliability of automated measurement algorithms. Lam et al.[13] measured mesiodistal tooth widths using manual methods, manual measurements on digital model (manual digital, MD) methods, and automated methods. They found no significant differences between measurement techniques, although the automated approach required the shortest processing time. Similarly, Martin et al.[14] evaluated the accuracy of a clear aligner (CA) planning software that performs automatic Bolton analysis, using digital caliper measurements as a reference standard. They reported a moderate correlation between the two methods.[14] Santana et al.[15] compared various measurement methods using ClinCheck, Dolphin Imaging, and 3D Slicer software, with digital caliper measurements on 3D-printed models serving as the gold standard. ClinCheck and Dolphin Imaging software yielded high accuracy in anterior Bolton analysis, but discrepancies were observed across methods when evaluating overall arch Bolton assessments.[15] The findings from automated and MD methods vary across treatment planning software programs. Therefore, this study evaluated the accuracy of automated Bolton ratio assessments performed by two CA planning software programs.

Materials and Methods

Ethical Considerations and Sample Size Determination

This retrospective study received ethical approval from İzmir Bakırçay University Ethics Committee (no. 2226, April 30, 2025).

Power analyses were performed using G*Power software (version 3.1.9.7) to achieve 95% power with an effect size of 0.25 and an alpha level of 5% (0.05), which required a minimum sample size of 40. Inclusion criteria were complete permanent dentition between right and left first molars in both arches, without anatomical variations such as microdontia, macrodontia, or restorations that could obscure interproximal border identification. Only nonextraction cases with no to mild crowding (≤4 mm) in both arches were included. The records of 40 patients who met the inclusion criteria and had started CAT at a private clinic were analyzed.

Manual Digital Method

Intraoral scans in stereolithography (STL) format of both the maxillary and mandibular arches of 40 patients who had previously initiated clear aligner therapy (CAT) with the Invisalign system were exported from the ClinCheck software (Align Technology, San Jose, CA, USA). The scans were uploaded to OrthoViewer software (3Shape, Denmark) for measurement using the MD method (Figure 1). Two researchers marked the mesial and distal borders of the teeth and recorded the tooth widths in millimeters. A total of 12 teeth were measured, from the right 1st molar to the left 1st molar, on each model. The measurements obtained using this procedure constituted the MD group, which served as the reference for comparison with the measurements derived from the two CAT software programs.

Automated Methods

Two CAT planning software programs were used for the automated method. The first was ClinCheck software, which is used for CAT planning within the Invisalign system. This software recorded the Bolton analysis results for the anterior (3-3) and posterior (6-6) segments, expressed as percentages, along with the mesiodistal widths of 12 teeth in both arches from each patient’s treatment planning page. The second software was DentOne (Diorco Co., Ltd., Korea), which offers both paid and free CA design and manufacturing services. Before model analysis, DentOne software requires the teeth to be segmented. Because the aim was to achieve a fully automated analysis, the segmentation process was carried out using an artificial intelligence (AI) tool, with no manual intervention to determine the mesiodistal boundaries of the teeth. The model analysis tool was used to record the mesiodistal widths of the teeth and the anterior and total Bolton ratios, which were automatically determined by the software.

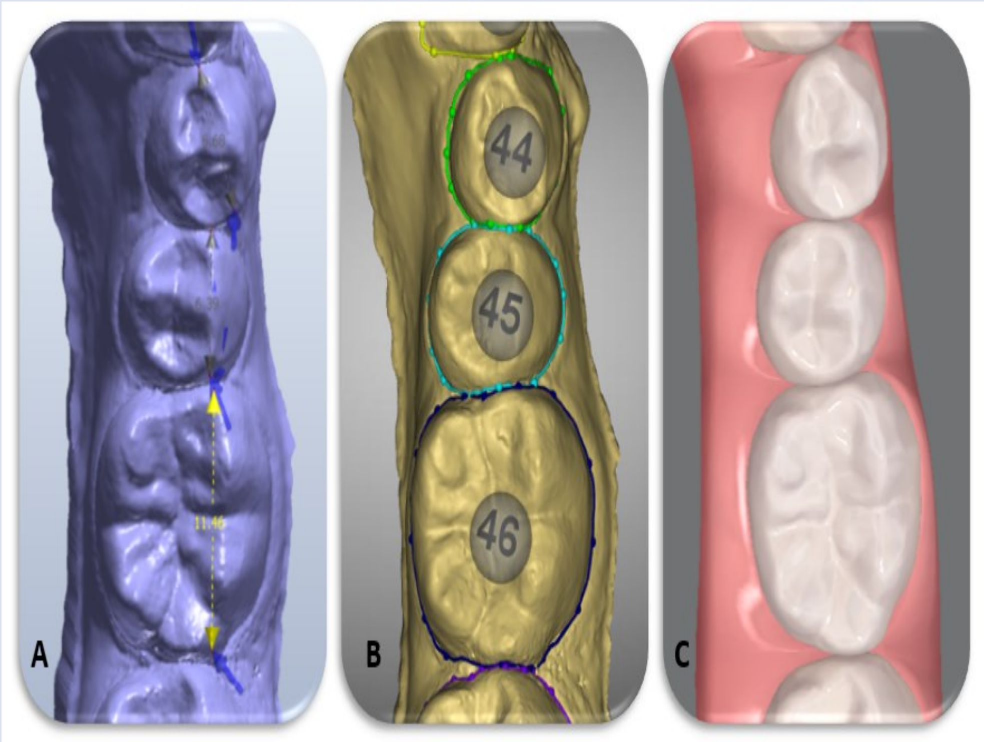

Figure 1. Segmentation and mesiodistal tooth width measurements obtained through different methods. (A) Manual digital measurement performed by the clinician. (B) Automated segmentation using DentOne software. (C) Automated segmentation using ClinCheck software.

Statistical Analysis

All statistical analyses were conducted using the Jamovi software version 2.3 (The Jamovi Project, Sydney, Australia). Descriptive statistics, including the mean, standard deviation, maximum values, minimum values, and 25th and 75th percentiles, were calculated for the data. The results of the Shapiro–Wilk normality test indicated that the data did not follow a normal distribution. The Kruskal–Wallis test was performed to compare the differences between the mesiodistal measurements and anterior and total Bolton values. The Mann–Whitney U test was used for post hoc pairwise comparisons between the groups. Statistical significance was accepted as $p < 0.05$. To assess measurement reliability, 10% of the samples measured manually were re-evaluated two weeks later. Intra- and interobserver agreement were assessed using intraclass correlation coefficients (ICCs). ICC values for intra-observer reliability ranged from 0.85 to 0.97, and interobserver reliability values ranged from 0.87 to 0.96, indicating a high level of agreement.

Results

The mean, standard deviation, minimum, maximum, and 25th and 75th percentile values of the anterior and total Bolton values were used to compare Bolton measurements. The anterior and total Bolton ratio measurements for the ClinCheck (C), manual digital (MD), and DentOne (D) groups are presented in Table 1. No significant differences were observed in the anterior Bolton ratios between the three methods ($p > 0.05$), indicating that all measurement approaches showed comparable accuracy in the anterior segment. The mean differences in the anterior Bolton values between groups C and MD, C and D, and D and MD were 1.68 ± 1.32 mm, 2.13 ± 2.72 mm, and 2.45 ± 2.78 mm, respectively. By contrast, the total Bolton ratios demonstrated significant differences ($p < 0.05$), with both ClinCheck and DentOne differing from the manual digital reference measurements ($p < 0.012$). The mean differences in total Bolton values between groups C and MD, C and D, and D and MD were 1.43 ± 1.45 mm, 1.88 ± 1.31 mm, and 2.69 ± 2.73 mm, respectively.

Table 2 provides the description and post hoc analysis of the C, D, and MD groups' maxillary right segment mesiodistal measurements. In intergroup comparisons, significant differences were observed between mean values for all teeth ($p < 0.05$). In the pairwise comparisons, significant differences were observed for tooth 11 between groups C and D and groups D and MD ($p < 0.001$). For tooth 13, significant differences were found between groups C and D and between groups C and MD ($p < 0.037$).

Additionally, for tooth 16, significant differences were detected between groups C and MD and between groups D and MD ($p < 0.001$), as well as between groups C and D and between groups D and MD ($p < 0.004$). In intragroup comparisons, a significant difference was observed in groups C and MD and groups D and MD. Intergroup and intragroup comparisons revealed a statistically significant difference between the mean values of all teeth and maxillary left segment mesiodistal measurements ($p < 0.05$; Table 3). In the intragroup comparisons, significant differences were found in groups C and D. These differences were attributed to teeth 23–26 and 24–26 ($p < 0.005$ and $p < 0.033$, respectively). The largest discrepancies were observed in the maxillary molars, where deviations were greater in both automated methods.

Table 1. Descriptives and post hoc statistical analysis of ClinCheck, Dentone, and Manual Digital groups' anterior and total Bolton values

Variables	Group C-Group MD				Group C-Group D				Group D-Group MD				p
	Mean ± SD	Min-Max	25-75%	Median	Mean ± SD	Min-Max	25-75%	Median	Mean ± SD	Min-Max	25-75%	Median	
Anterior Bolton Values	1.68 ± 1.32	0.04-5.12	0.58-2.83	1.36	2.13 ± 2.72	0.03-13.8	0.37-2.32	1.48	2.45 ± 2.78	0.02-11.3	0.50-3.21	1.60	0.821
Total Bolton Values	1.43 ± 1.45	0.07-8.30	0.43-1.92	1.04^{A}	1.88 ± 1.31	0.06-10.5	0.64-2.42	1.31^{AB}	2.69 ± 2.73	0.20-13.3	0.92-3.14	2.36^{B}	0.014*
p	0.281				0.981				0.324				

*Group C: Group ClinCheck, Group D: Group Dentone, Group MD: Group Manual Digital. SD: Standard Deviation, Min: Minimum, Max: Maximum, 25%: 25 quartile values, 75%: 75 quartile values. *There is a statistically significant difference at P<.05. Same letters show statistical differences in rows.*

Table 2. Descriptives and post hoc statistical analysis of ClinCheck, Dentone, and Manual Digital groups' maxillary right segment

	Group C-Group MD				Group C-Group D				Group D-Group MD				p
	Mean ± SD	Min-Max	25-75%	Median	Mean ± SD	Min-Max	25-75%	Median	Mean ± SD	Min-Max	25-75%	Median	
11	0.39 ± 0.29	0.01-1.54	0.23-0.49	0.33^{AB}	0.33 ± 0.46	0.00-2.47	0.11-0.38	0.24^{A}	0.60 ± 0.52	0.02-2.99	0.26-0.78	0.47^{B}	<.001*
12	0.36 ± 0.30	0.01-1.25	0.17-0.51	0.23^{C}	0.43 ± 0.34	0.00-1.50	0.19-0.59	0.39^{C}	0.67 ± 0.48	0.06-2.10	0.22-0.94	0.70^{D}	0.006*
13	0.34 ± 0.23	0.03-0.89	0.18-0.48	0.30^{E}	0.22 ± 017	0.01-0.67	0.08-0.30	0.20^{F}	0.44 ± 027	0.06-1.21	0.23-0.60	0.40^{E}	<.001*
14	0.27 ± 0.21	0.02-0.82	0.11-0.39	0.20^{GH}	0.22 ± 0.24	0.00-1.40	0.09-0.31	0.15^{G}	0.38 ± 0.34	0.01-1.65	0.20-0.40	0.27^{H}	0.015*
15	0.32 ± 0.22	0.00-0.87	0.17-0.44	0.29^{I}	0.35 ± 0.33	0.00-1.40	0.09-0.56	0.21^{I}	0.55 ± 0.34	0.01-1.27	0.26-0.79	0.53^{J}	0.003*
16	0.45 ± 0.27	0.01-1.01	0.17-0.64	0.47^{K}	0.64 ± 0.60	0.06-3.70	0.29-0.79	0.57^{K}	0.95 ± 0.60	0.15-3.57	0.53-1.24	0.87^{L}	<.001*
p	<.001*				0.052				<.001*				

*Group C: Group ClinCheck, Group D: Group Dentone, Group MD: Group Manual Digital. SD: Standard Deviation, Min: Minimum, Max: Maximum, 25%: 25 quartile values, 75%: 75 quartile values. *There is a statistically significant difference at P<.05. Same letters show statistical differences in rows.*

Table 3. Descriptives and post hoc statistical analysis of ClinCheck, Dentone, and Manual Digital groups' maxillary left segment

	Group C-Group MD				Group C-Group D				Group D-Group MD				p
	Mean ± SD	Min-Max	25-75%	Median	Mean ± SD	Min-Max	25-75%	Median	Mean ± SD	Min-Max	25-75%	Median	
21	0.43 ± 0.32	0.01-1.31	0.16-0.60	0.37^{A}	0.28 ± 0.34	0.01-1.58	0.09-0.31	0.17^{B}	0.60 ± 0.46	0.02-1.95	0.24-0.75	0.52^{A}	<.001*
22	0.39 ± 0.24	0.01-1.04	0.22-0.53	0.41^{C}	0.25 ± 0.18	0.01-0.90	0.14-0.36	0.22^{D}	0.50 ± 0.34	0.01-1.25	0.17-0.75	0.51^{C}	0.001*
23	0.39 ± 0.30	0.03-1.29	0.15-0.61	0.34^{E}	0.27 ± 0.44	0.02-2.15	0.07-0.25	0.14^{F}	0.44 ± 0.36	0.02-1.86	0.14-0.60	0.36^{E}	0.001*
24	0.29 ± 0.21	0.02-0.92	0.11-0.42	0.29^{GH}	0.25 ± 0.26	0.01-1.19	0.06-0.33	0.17^{G}	0.43 ± 0.30	0.02-1.28	0.22-0.62	0.34^{H}	0.006*
25	0.27 ± 0.26	0.03-1.28	0.10-0.36	0.19^{I}	0.27 ± 0.26	0.03-1.28	0.10-0.36	0.19^{I}	0.53 ± 0.34	0.04-1.66	0.30-0.72	0.48^{J}	<.001*
26	0.54 ± 0.38	0.01-1.40	0.15-0.84	0.56^{K}	0.48 ± 0.57	0.05-3.51	0.20-0.55	0.36^{K}	0.89 ± 0.64	0.01-3.49	0.42-1.16	0.84^{L}	<.001*
p	0.004*				0.005*				<.001*				

*Group C: Group ClinCheck, Group D: Group Dentone, Group MD: Group Manual Digital. SD: Standard Deviation, Min: Minimum, Max: Maximum, 25%: 25 quartile values, 75%: 75 quartile values. *There is a statistically significant difference at P<.05. Same letters show statistical differences in rows.*

Descriptive and post hoc statistical analyses of all groups' mandibular left segment teeth are provided in Table 4. In this segment, teeth 31, 32, 35, and 36 showed significant differences in mesiodistal measurements among all groups ($p < 0.05$). An intragroup difference was only present in groups C and D ($p < 0.05$). In the pairwise comparisons, statistically significant differences were observed for teeth 31 and 32 between groups C and D ($p < 0.017$).

Table 5 illustrates the statistical analyses for the mandibular right segment teeth. Intergroup differences were present in all teeth except tooth 44 ($p < 0.05$). In pairwise comparisons, significant differences were observed for tooth 41 between groups C and MD and between groups D and MD ($p < 0.024$). For the same tooth, significant differences were also found between groups C and D and between groups D and MD ($p < 0.001$). For tooth 43, significant differences were detected between groups C and D and between groups D and MD ($p < 0.028$). For tooth 46, significant differences were observed between groups C and D and between groups D and MD ($p < 0.014$). Intragroup comparisons of the mesiodistal measurements of the mandibular right segment showed no significant differences in the mean values of all teeth ($p > 0.05$).

Table 4. Descriptives and post hoc statistical analysis of ClinCheck, Dentone, and Manual Digital groups' mandibular left segment.

	Group C-Group MD				Group C-Group D				Group D-Group MD				p
	Mean ± SD	Min-Max	25-75%	Median	Mean ± SD	Min-Max	25-75%	Median	Mean ± SD	Min-Max	25-75%	Median	
31	0.26 ± 0.17	0.01-0.73	0.11-0.36	0.27^{A}	018 ± 0.16	0.00-0.82	0.09-0.21	0.16^{B}	0.34 ± 0.22	0.02-0.76	0.11-0.49	0.37^{A}	0.004*
32	0.31 ± 0.30	0.01-1.53	0.13-0.38	0.27^{C}	0.40 ± 0.37	0.01-1.53	0.13-0.51	0.26^{CD}	0.57 ± 0.40	0.04-1.61	0.27-0.84	0.51^{D}	0.003*
33	0.36 ± 0.44	0.00-2.58	0.10-0.43	0.25	0.36 ± 0.44	0.00-2.58	0.10-0.43	0.25	0.48 ± 0.46	0.02-2.77	0.21-0.66	0.35	0.109
34	0.24 ± 0.18	0.01-0.75	0.08-.033	0.24	0.27 ± 0.30	0.00-1.63	0.09-0.33	0.19	0.37 ± 0.37	0.00-1.95	0.11-0.48	0.26	0.297
35	0.32 ± 0.21	0.00-0.82	0.17-0.45	0.31^{EF}	0.37 ± 0.49	0.01-2.73	0.11-0.44	0.24^{E}	0.55 ± 0.58	0.01-3.07	0.22-0.65	0.46^{F}	0.017*
36	0.39 ± 0.26	0.01-1.14	0.18-0.56	0.32^{G}	0.28 ± 0.43	0.00-2.59	0.07-0.27	0.19^{H}	0.49 ± 0.42	0.01-2.41	0.24-0.58	0.36^{G}	<.001*
p	0.143				0.025*				0.053				

*Group C: Group ClinCheck, Group D: Group Dentone, Group MD: Group Manual Digital. SD: Standard Deviation, Min: Minimum, Max: Maximum, 25%: 25 quartile values, 75%: 75 quartile values. *There is a statistically significant difference at P<.05. Same letters show statistical differences in rows.*

Table 5. Descriptives and post hoc statistical analysis of ClinCheck, Dentone, and Manual Digital groups' mandibular right segment

	Group C-Group MD				Group C-Group D				Group D-Group MD				p
	Mean ± SD	Min-Max	25-75%	Median	Mean ± SD	Min-Max	25-75%	Median	Mean ± SD	Min-Max	25-75%	Median	
41	0.27 ± 0.20	0.01-0.87	0.13-0.35	0.24^{A}	0.20 ± 0.13	0.01-0.70	0.09-0.27	0.19^{A}	0.38 ± 0.20	0.05-0.83	0.20-0.53	0.38^{B}	<.001*
42	0.27 ± 0.18	0.00-0.70	0.14-0.41	0.28^{C}	0.31 ± 0.28	0.00-1.42	0.14-0.38	0.25^{C}	0.51 ± 0.30	0.05-1.27	0.24-0.72	0.55^{D}	<.001*
43	0.36 ± 0.28	0.01-1.16	0.15-0.52	0.28^{EF}	0.29 ± 0.25	0.01-1.06	0.07-0.41	0.26^{E}	0.50 ± 0.37	0.00-1.33	0.15-0.78^{F}	0.50	0.031*
44	0.28 ± 0.21	0.01-0.93	0.15-0.44	0.21	0.28 ± 0.52	0.00-3.27	0.08-0.27	0.17	0.40 ± 0.60	0.00-3.79	0.11-0.46	0.30	0.108
45	0.31 ± 0.22	0.01-0.98	0.12-0.45	0.31^{GH}	0.28 ± 0.29	0.01-1.23	0.08-0.34	0.20^{G}	0.47 ± 0.34	0.01-1.75	0.27-0.64	0.38^{H}	0.003*
46	0.38 ± 0.26	0.01-1.03	0.17-0.56	0.37^{IJ}	0.39 ± 0.55	0.02-2.52	0.07-0.47	0.22^{I}	0.61 ± 0.56	0.02-2.53	0.22-0.78	0.50^{J}	0.010*
p	0.365				0.380				0.052				

*Group C: Group ClinCheck, Group D: Group Dentone, Group MD: Group Manual Digital. SD: Standard Deviation, Min: Minimum, Max: Maximum, 25%: 25 quartile values, 75%: 75 quartile values. *There is a statistically significant difference at P<.05. Same letters show statistical differences in rows.*

Discussion

In CAT, optimal aligner fit is a key determinant of treatment efficiency and successful planned tooth movements. The planning process typically begins with segmentation and automated tooth size analysis, facilitated by AI or performed manually by the clinician through dental landmark annotation.[16] Inaccuracies in automatic tooth segmentation and mesiodistal width measurements can adversely affect aligner fit, compromising treatment outcomes. Such measurement errors may result in suboptimal planning of IPR or restorative procedures.[17] In this context, our study evaluated the performance of mesiodistal tooth width measurements and Bolton analysis automatically performed by two CAT planning software programs—ClinCheck and DentOne—by comparing them with clinician-generated digital measurements. We observed significant differences between the software-generated and MD methods. However, when the width of each individual tooth was assessed, the deviation from the MD method was less than 1 mm across all software programs.

ClinCheck yielded measurements that aligned more closely with the MD method than those produced by DentOne across all evaluated parameters. ClinCheck uses AI-based algorithms that have been optimized over many years using large datasets.[18,19] This may contribute to more accurate outcomes, particularly in the automatic identification of tooth boundaries and contact points, with minimal user intervention. DentOne provides a semiautomatic segmentation method in addition to its AI-based segmentation tool, which allows users to manually define tooth boundaries using reference points. Because our study evaluated the performance of fully automated measurement in both software programs, the AI-based segmentation tool was used in DentOne without user input. In cases with significant morphological variation or dental crowding, incorporating the manual landmarking option in DentOne may improve the accuracy of tooth segmentation and width measurements.

Molars serve as essential anchorage units during biomechanically demanding movements such as arch intrusion, distalization, and space closure in extraction cases, playing a key role in orthodontic treatment planning.[20,21] Errors that occur during the segmentation process can directly affect subsequent tooth size measurements performed by the software. In our study, the magnitude of deviation in mesiodistal width measurements obtained through automated methods varied between the anterior and posterior teeth. For both software programs, the greatest deviation was found in the maxillary molars. Specifically, for teeth 26 and 16, the average deviations from the MD method were 0.56 mm and 0.47 mm for ClinCheck and 0.84 mm and 0.87 mm for DentOne, respectively. ClinCheck showed closer agreement with the MD measurements than DentOne, indicating higher measurement consistency. Similarly, Santana et al.[15] evaluated the diagnostic performance of ClinCheck, Dolphin Imaging, and 3D Slicer software based on the Bolton discrepancy index. ClinCheck provided more accurate results for anterior Bolton calculations but exhibited significant deviations from the reference standard in posterior measurements. Shailendran et al. evaluated the accuracy and reliability of tooth width measurements and Bolton ratios obtained using ClinCheck Pro.[11] The authors reported that ClinCheck Pro underestimated tooth widths by an average of 0.36 mm; this discrepancy reached up to 0.9 mm in first molars. The major deviations observed in molar measurements compared with the other teeth may be influenced by several factors. Because these teeth are located in the posterior region of the arch, intraoral scanning in the buccal corridor is performed within a restricted space, limited by the cheeks, tongue, and mandibular movements. This may reduce the scanning accuracy by narrowing the field of view. Furthermore, molars are bulkier and exhibit more complex morphology than other teeth. Martin et al. noted that tooth width measurements obtained using ClinCheck Pro 6.0 were accurate and clinically acceptable for all teeth except the molars.[14] Tubercles, fissures, and marginal ridges may hinder the scanner's ability to capture complete surface data, resulting in data loss. Incomplete or inaccurate surface information can negatively affect the digital matching processes used by the scanner to merge segmented data. Therefore, it is essential that clinicians perform highly accurate intraoral scans of molar teeth to minimize the need for subsequent software-based corrections. Software-based analyses should be performed cautiously because of the increased risk of measurement errors in the molar region.

Following the molar measurements, the second-largest deviations in both software programs were observed in the incisor region. Compared with the MD method, DentOne showed a 0.70 mm deviation for tooth 12, and ClinCheck showed a 0.41 mm deviation for tooth 22. The increased deviation in incisor measurements may be associated with tooth inclination. Identifying contact points may become more challenging in arches with retroclined incisors or anterior crowding. Yu et al. comprehensively evaluated the differences between automatic and MD methods across multiple parameters, including tooth width, anterior and posterior Bolton analysis, intercanine width, and intermolar width.[22] They reported a 0.16 mm difference in individual tooth width measurements between the two methods, which they attributed to variations in tooth axes and measurement points. In future studies, accuracy analyses should be conducted within subgroups based on different tooth axes and incisor inclination angles to provide more detailed results.

Our study has several limitations. Only arches with mild crowding were included. The degree and location of crowding may influence the accuracy of segmentation and the identification of contact points by the software. Therefore, forming subgroups based on the severity and location of crowding may provide more comprehensive results. Expanding the sample size and incorporating teeth with greater anatomical variation could enhance the clinical applicability of the findings.

Conclusions

Although the mesiodistal width measurements and Bolton analysis results generated by the ClinCheck and DentOne CAT planning software are clinically acceptable, they showed significant differences compared with those obtained manually using digital software. These discrepancies were more pronounced in the maxillary molars, where anatomical complexity and scanning limitations may compromise accuracy. Therefore, precise intraoral scanning is essential for reliable measurements. Clinicians should interpret automated Bolton assessments with caution and consider manual verification when necessary.

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Conflicts of Interest Statement

The authors declare no conflicts of interest.

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