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Turkish Journal of Orthodontics (Turk J Orthod) is an international, scientific, open access periodical published in accordance with independent, unbiased, and double-blinded peer-review principles. The journal is the official publication of Turkish Orthodontic Society and it is published quarterly on March, June, September and December.

Turkish Journal of Orthodontics publishes clinical and experimental studies on on all aspects of orthodontics including craniofacial development and growth, reviews on current topics, case reports, editorial comments and letters to the editor that are prepared in accordance with the ethical guidelines. The journal's publication language is English and the Editorial Board encourages submissions from international authors.

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Keywords: Each submission must be accompanied by a minimum of three to a maximum of six keywords for subject indexing at the end of the abstract. The keywords should be listed in full without

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TYPE OF MANUSCRIPT	WORD LIMIT	ABSTRACT WORD LIMIT	REFERENCE LIMIT	TABLE LIMIT	FIGURE LIMIT
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REVIEW ARTICLE	5000	250	50	6	10 or total of 20 images
CASE REPORT	1000	200	15	No tables	10 or total of 20 images
LETTER TO THE EDITOR	500	No abstract	5	No tables	No media

Tables

Tables should be included in the main document, presented after the reference list, and they should be numbered consecutively in the order they are referred to within the main text. A descriptive title must be placed above the tables. Abbreviations used in the tables should be defined below the tables by footnotes (even if they are defined within the main text). Tables should be created using the "insert table" command of the word processing software and they should be arranged clearly to provide easy reading. Data presented in the tables should not be a repetition of the data presented within the main text but should be supporting the main text.

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Where necessary, authors should Identify teeth using the full name of the tooth or the FDI annotation.

All acronyms and abbreviations used in the manuscript should be defined at first use, both in the abstract and in the main text. The abbreviation should be provided in parentheses following the definition.

When a drug, product, hardware, or software program is mentioned within the main text, product information, including the name of the product, the producer of the product, and city and the country of the company (including the state if in USA), should be provided in parentheses in the following format: "Discovery St PET/CT scanner (General Electric, Milwaukee, WI, USA)"

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Book Section: Suh KN, Keystone JS. Malaria and babesiosis. Gorbach SL, Barlett JG, Blacklow NR, editors. Infectious Diseases. Philadelphia: Lippincott Williams; 2004.p.2290-308.

Books with a Single Author: Sweetman SC. Martindale the Complete Drug Reference. 34th ed. London: Pharmaceutical Press; 2005.

Editor(s) as Author: Huizing EH, de Groot JAM, editors. Functional reconstructive nasal surgery. Stuttgart-New York: Thieme; 2003.

Conference Proceedings: Bengisson S. Sothemin BG. Enforcement of data protection, privacy and security in medical informatics. In: Lun KC, Degoulet P, Piemme TE, Rienhoff O, editors. MEDINFO 92. Proceedings of the 7th World Congress on Medical Informatics; 1992 Sept 6-10; Geneva, Switzerland. Amsterdam: North-Holland; 1992. pp.1561-5.

Scientific or Technical Report: Cusick M, Chew EY, Hoogwerf B, Agrón E, Wu L, Lindley A, et al. Early Treatment Diabetic Retinopathy Study Research Group. Risk factors for renal replacement therapy in the Early Treatment Diabetic Retinopathy Study (ETDRS), Early Treatment Diabetic Retinopathy Study Kidney Int: 2004. Report No: 26.

Thesis: Yılmaz B. Ankara Üniversitesindeki Öğrencilerin Beslenme Durumları, Fiziksel Aktiviteleri ve Beden Kitle İndeksleri Kan Lipidleri Arasındaki Ilişkiler. H.Ü. Sağlık Bilimleri Enstitüsü, Doktora Tezi. 2007.

Manuscripts Accepted for Publication, Not Published Yet: Slots J. The microflora of black stain on human primary teeth. Scand J Dent Res. 1974.

Epub Ahead of Print Articles: Cai L, Yeh BM, Westphalen AC, Roberts JP, Wang ZJ. Adult living donor liver imaging. Diagn Interv Radiol. 2016 Feb 24. doi: 10.5152/dir.2016.15323. [Epub ahead of print].

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Accepted manuscripts are copy-edited for grammar, punctuation, and format. Once the publication process of a manuscript is completed, it is published online on the journal's webpage as an ahead-of-print publication before it is included in its scheduled issue. A PDF proof of the accepted manuscript is sent to the corresponding author and their publication approval is requested within 2 days of their receipt of the proof.

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TURKISH JOURNAL of ORTHODONTICS

Contents

Original Articles

Review

TURKISH JOURNAL of ORTHODONTICS

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Original Article

Association Between Impacted Maxillary Canines and Adjacent Lateral Incisors: A Retrospective Study With Cone Beam Computed Tomography

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Main Points

- The maxillary lateral incisors play an important role on maxillary canine impaction.
- Smaller sized lateral incisors are significant etiologic factors of maxillary canine impaction.
- Angulation of the lateral incisor to midline and axis of the adjacent canine are defined as predictors of maxillary canine impaction.

ABSTRACT

Objective: The goal of this study was to evaluate the association between the morphologic characteristics of maxillary lateral incisors and maxillary canine impaction by using cone beam computed tomography (CBCT) images.

Methods: CBCT images of 52 patients (19 male and 33 female) with unilateral impacted maxillary canines were selected. The volume, root, and total lengths of the lateral incisor, mesiodistal and buccolingual widths of the lateral incisor crowns, angles between the central axis of the lateral incisor and the midline, occlusal plane, and the central axis of canines in both the impacted and non-impacted side were measured and compared.

Results: Statistically significant differences were obtained when comparing the volume of the lateral incisor, the mesiodistal and buccolingual widths of the lateral incisor crown, the root and total lengths of the lateral incisors, and angles between the central axis of the lateral incisor and the midline and the central axis of the adjacent canine ($P < .05$). There were no significant differences in lateral incisor axis and the maxillary occlusal plane angulation.

Conclusion: The association between the morphologic and angular features of the maxillary lateral incisors and maxillary canine impaction was confirmed. The volume of the lateral incisor, mesiodistal and buccolingual width of the lateral incisor crown, root and the total length of the lateral incisor, and the lateral incisor angulation to the midline and the axis of adjacent canine were found to be strong predictors of maxillary canine impaction.

Keywords: Maxillary canine impaction, lateral incisor length, lateral incisor width, lateral incisor volume, cone beam computed tomography

INTRODUCTION

Permanent maxillary canines are the most frequently impacted teeth with the exception of the third molars, with the prevalence of impaction of 1% to 5%.[1] Maxillary canine impaction is more frequently seen palatally and unilaterally. It also has higher incidence in females than in males.[2]

At the beginning of its eruption, the maxillary canine's tooth bud is located below the orbital floor and needs to descend 22 mm to reach its final occlusal position.[2] During the mixed dentition stage, the permanent maxillary canine is inclined mesially and positioned high along the distal side of the apical third of the maxillary

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lateral incisor root, which acts as a guide along which the canine erupts while simultaneously uprighting its mesial inclination. Meanwhile, root development of the lateral incisors is close to completion at this stage. These teeth inherently affect the canines' eruption pathway, and anomalies in their size, shape, and number are considered to lay the foundations of one of the etiologic theories of maxillary canine impaction, especially of the palatal side. Therefore, the incidence of maxillary canine impaction would be relatively greater in patients with peg-shaped or missing maxillary lateral incisors, as the guiding function of the maxillary lateral incisors' root is lost.[2-5]

It is established that morphologic anomalies of the maxillary lateral incisors have a close association with maxillary canine impaction.[6-8] Moreover, there is a significant decrease in the mesiodistal width of the maxillary teeth in patients with canine impaction.[7,9] Supporting this theory, studies have been conducted to establish that maxillary canine impaction is associated with the morphology of the lateral incisor.[7] Therefore, although the exact etiology of the impacted canines is not known, it seems that the adjacent lateral incisor plays a critical role, because the eruption of the maxillary canine and the adjacent lateral incisor's size and eruption are controlled by the same genes.[10]

Cone beam computed tomography (CBCT) is a radiographic technique which is used in dentistry, including orthodontics. High-quality diagnostic three-dimensional (3D) images presented by CBCT can be analyzed at any dimension. This makes angular, linear, and volumetric measurements more reproducible and accurate.[11,12]

The rationale behind beginning our study was to determine the possibility of the maxillary canine impaction even on the 2D images, by detecting early determinants associated with the adjacent lateral incisors that are effective in maxillary canine impaction. The primary purpose of this study was to analyze and compare the morphologic characteristics of the maxillary lateral incisors on impacted and non-impacted sides in cases presenting unilateral maxillary canine impaction, by using 3D-reconstructed CBCT images. The secondary aim was to corroborate the association between the features of the maxillary lateral incisor and maxillary canine impaction.

METHODS

CBCT images of 52 patients (19 male and 33 female, average age of 20.8 years) presenting unilateral maxillary canine impaction were selected from the archives of dental faculties (Başkent University and Eskişehir Osmangazi University)

Table 1. Demographic characteristics of patients included in the study

Gender	*N*	Average Age	Age (Min-Max)
Woman	33	19.8 years	12.8-37.5
Man	19	22.7 years	12.5-36.2
Total	52	20.8 years	12.5-37.5

N, number; Min-Max, minimum and maximum values.

(Table 1). The patients had already given written informed consent to their clinics to use their personal data, and our University Institutional Review Board approved this study to use the universities' archives (Project no: Project no: D-KA 19/21).

Alqerban et al.'s[13] study was taken into consideration for power analysis. The sample size was determined by power analysis to detect statistical significance of 80% power and 5% error ratio with 0.4 effect size. The inclusion criteria were the unilateral impaction of maxillary permanent canines, both maxillary lateral incisors present and erupted, and no dentofacial deformities or systemic diseases.

In the study, 28 of the CBCT images were acquired with the Morita 3D Accuitomo 170 (J Morita, Kyoto, Japan) device (90 kV, 5 mA, 0.08, 0.125, 0.160, 0.200 mm voxel size and 100 × 50 FOV), and 24 of the CBCT images were obtained using a Promax 3D Mid (Planmeca, Helsinki, Finland) machine (94 kVp, 14 mA, 0.200 mm voxel size and 130 × 90 mm or 130 × 55 mm FOV).

All of the data sets were exported and converted using the Digital Imaging and Communications in Medicine format. Images were created and measurements were carried out using Dolphin Imaging & Management Solutions software program (Version 11.5 Premium, Patterson Dental, CA, USA) (Figure 1). To aid better visuals and avoid errors during the point selection, the enlarging, contrast, and brightness features of the software program were used. All data were measured in millimeter, cubic millimeter or angle, and the same experienced investigator made all landmark identifications and measurements to prevent inter-observer variability.

In this study, only patients with unilateral canine impaction either on the left or right sides were selected. Furthermore, morphological characteristics and angular features of the adjacent lateral incisor were measured to compare the impacted and non-impacted sides. For this purpose, the volume, root, and total lengths of the lateral incisor tooth, the mesiodistal and buccolingual widths of the lateral incisor crown, the angles between the central axis of the lateral incisor and the midline, the maxillary occlusal plane, and the central axis of canine were measured. The line passing through the crista galli and the anterior nasal spine was used as midline and the line passing through the

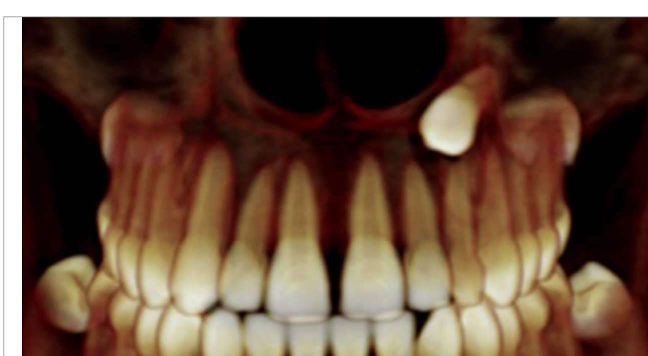

Figure 1. Volumetric rendered image with the surrounding structures.

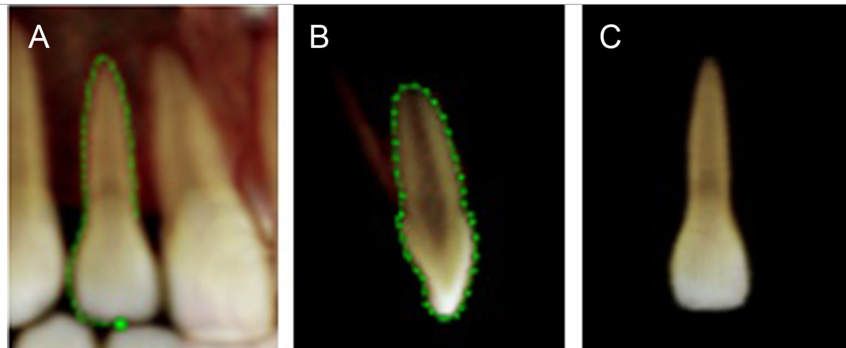

Figure 2. A-C. (A) Maxillary right lateral incisor's boundaries were drawn from the crown tip to the root apex on the coronal plane; (B) Drawing the lateral incisor's boundaries on the sagittal plane; (C) Maxillary right lateral incisor separated from the surrounding structures on 3D image using the Dolphin Imaging & Management Solutions software program.

mesiobuccal cusp of the maxillary first molar and incisal edge of the maxillary central incisor was used as maxillary occlusal plane.

Images were oriented on the lines of the anterior nasal spine and posterior nasal spine, and the midsagittal line was also determined before the measurements carried out. We determined the midsagittal plane through the crista galli, anterior nasal spine, and posterior nasal spine. In addition, we used reference planes while measuring the angles. The axial plane was through the anterior nasal spine and posterior nasal spine, and perpendicular to the sagittal plane. The coronal plane was determined through the anterior nasal spine and perpendicular to the sagittal and axial planes. The angle between the lateral incisor and occlusal plane was measured on the sagittal plane. The lateral incisor and canine angle and the lateral incisor and midline angle were measured on the frontal (coronal) plane.

For the volumetric measurements, Dolphin software offered the opportunity to draw the outer boundaries of the tooth on the volumetric rendered image with the "use volume sculpting" command. After drawing the boundaries of the lateral incisor, it could be separated from the surrounding structures by using the "cut" tool of the program. First, we drew the lateral incisor's boundaries from the crown tip to the apex tip by following the border of the tooth on the coronal plane, and separated it from surrounding structures by the "cut" tool (Figure 2A). Then, the same process was repeated on the other planes (Figure 2B). Finally, lateral incisor was separated from other structures in all planes, and the approximate volume of the tooth, which was isolated, was measured by using the "volume" command. We could measure the approximate volume by using this procedure (Figure 2C).

The buccolingual and mesiodistal widths of the lateral incisor crowns were measured from the widest point of the crown perpendicular to the long axis on the sagittal and the coronal section, respectively (Figure 3A and B). The length of the root was measured from the lowest buccal cementoenamel junction (CEJ) level to the root apex, and the total length of the lateral incisor was measured from the incisal tip to the root apex on the sagittal section (Figure 3C).

The angles between the axis of the lateral incisor and the midline (Figure 4A) and the axis of the canine were measured from the frontal view of the CBCT image (Figure 4B and 4C). From the sagittal view, the angle between the axis of the lateral incisor and maxillary occlusal plane was measured (Figure 5).

All of the parameters were reanalyzed by the same researcher 11 days after the last measurement, on 13 of the randomly selected CBCT images to assess intra-observer reliability using the intraclass correlation coefficient. The margin of error was statistically insignificant.

Statistical Analysis

Data analysis was performed using IBM SPSS Statistics Version 17.0 software (IBM Corporation, Armonk, NY, USA). The normality of distributions was tested using the Shapiro–Wilk test.

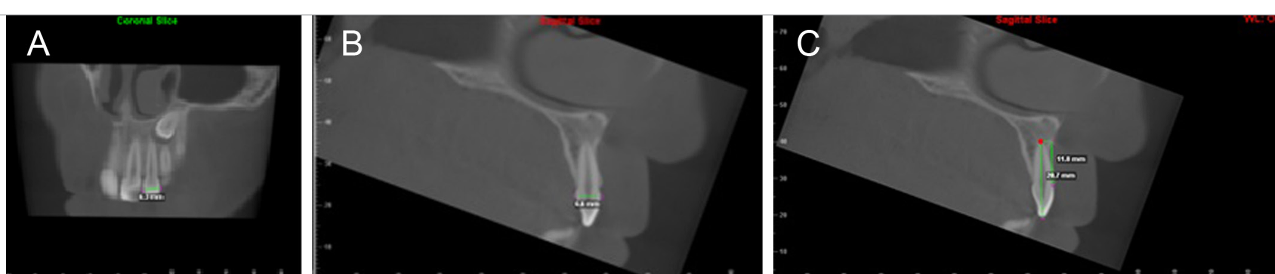

Figure 3. A-C. (A) Mesiodistal width of the crown measured from the widest point of the crown on the coronal section; (B) Buccolingual width of the crown measured from the widest point of the crown on the sagittal section; (C) Length of the root measured from the lowest buccal CEJ level to the root apex and total length of the lateral incisor measured from the incisal tip to the root apex on the sagittal section.

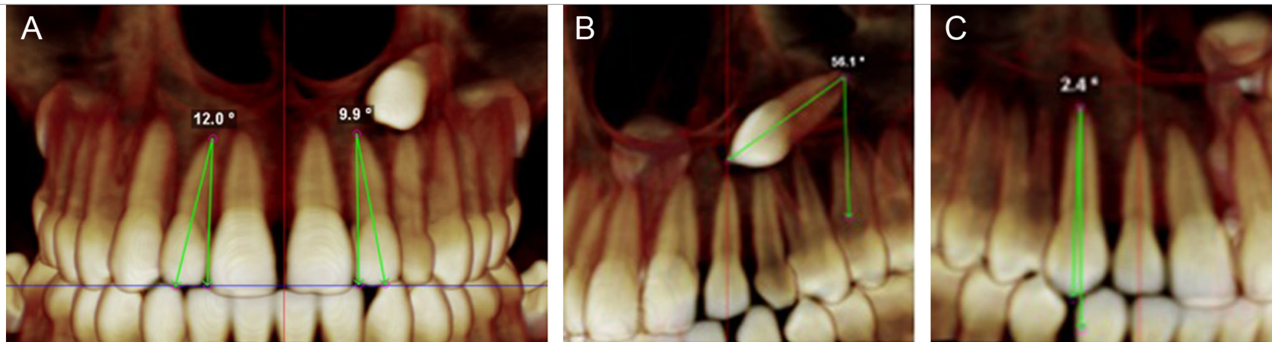

Figure 4. A-C. (A) The angle measured between the axis of the lateral incisor and the line parallel to midline; (B) The angle measured between the line parallel to axis of the lateral incisor and the axis of the canine on the left side; (C) The angle measured between the line parallel to axis of the lateral incisor and the axis of the canine on the right side.

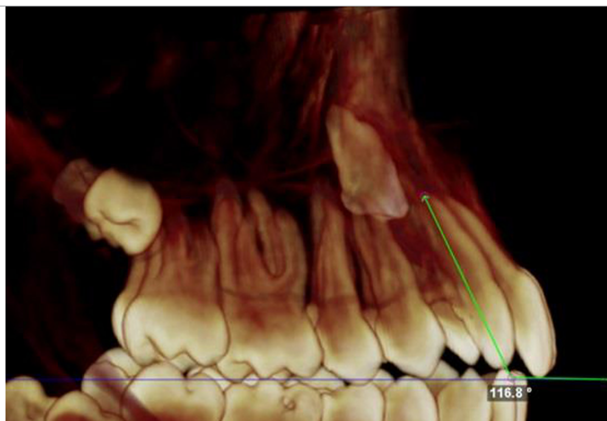

Figure 5. The angle measured between the axis of the lateral incisor and the line parallel to the maxillary occlusal plane.

Descriptive statistics for continuous variables were expressed as mean ± SD and median (min-max). The differences in linear and angular measurements between impacted and non-impacted sides were evaluated using the paired *t*-test or the Wilcoxon Signed-Rank test, where appropriate. Intra-class correlation coefficients and 95% confidence intervals were also calculated for both linear and angular measurements to examine intra-observer agreement (reliability) levels (Table 2). A *P* value less than .05 was considered as statistically significant.

Table 2. Intra-class correlation coefficients and 95% CIs for intra-observer reliability

Measurements	Impacted Side	Non-impacted Side
U2 BL (mm)	0.897 (0.696-0.969)	0.902 (0.707-0.970)
U2 MD (mm)	0.970 (0.905-0.991)	0.836 (0.542-0.949)
U2tl (mm)	0.990 (0.966-0.997)	0.969 (0.899-0.991)
U2rl (mm)	0.990 (0.967-0.997)	0.976 (0.922-0.993)
U2v (mm^3)	0.994 (0.980-0.998)	0.994 (0.981-0.998)
U2^ML (°)	0.959 (0.870-0.988)	0.968 (0.897-0.991)
U3^U2 (°)	0.994 (0.981-0.998)	0.958 (0.868-0.988)
U2^MOP (°)	0.994 (0.981-0.998)	0.995 (0.985-0.999)

U2, maxillary lateral incisor; U3, maxillary canine.
BL, buccolingual width; MD, mesiodistal width; tl, total length; rl, root length; v, volume; ML, Midline; MOP, maxillary occlusal plane.

RESULTS

Intra-observer agreement levels were found to be clinically acceptable and highly reliable in terms of both linear and angular measurements, on both impacted and non-impacted sides ($P < .001$). Intra-observer agreement (reliability) levels ranged from 0.836 to 0.995.

Descriptive statistics and comparisons for the linear and angular measurements between the impacted and non-impacted sides are shown in Table 3.

The buccolingual and mesiodistal widths of the lateral incisor crown were significantly smaller on the impacted side than that on the non-impacted side ($P < .05$). The mean buccolingual width of the lateral incisor crown was 6.6 mm on the impacted side and 6.9 mm on the non-impacted side. The mean mesiodistal width of the lateral incisor crown was 6.6 mm on the impacted side and 6.9 on the non-impacted side.

There were significant differences in both the root length and total length of the maxillary lateral incisors between the 2 sides ($P < .05$). Root length of the lateral incisor on the impacted side (13.1 mm) was shorter compared to the non-impacted side (14 mm) ($P < .05$). Similarly, the total length of the lateral incisor on the impacted side was 21 mm, whereas it was 22 mm on the non-impacted side.

The mean maxillary lateral incisor volume was also significantly smaller (376 mm^3) on the impacted side compared to the non-impacted side (400 mm^3), by 31.4% ($P < .05$).

Significant differences were determined for the angular measurements between impacted and non-impacted sides ($P < .001$). Angulation between the maxillary lateral incisor axis and midline was higher for the non-impacted side, with a mean of 16.4°, compared with 11° for the impacted side.

There were no significant differences in the angulation between the lateral incisor axis and the maxillary occlusal plane ($P > .05$). The maxillary lateral incisors created an angle of 96.5°and 91.4° with the maxillary occlusal plane on the impacted and non-impacted sides, respectively.

Table 3. Comparison between impacted and non-impacted sides

Measurements	Impacted Side		Non-Impacted Side		P
	Mean ± SD	Median	Mean ± SD	Median	
U2 BL (mm)	6.68 ± 0.76	6.60	6.87 ± 0.63	6.90	.013‡
U2 MD (mm)	6.60 ± 0.82	6.60	6.77 ± 0.64	6.90	.026‡
U2tl (mm)	20.48 ± 2.71	20.80	21.57 ± 2.1	21.85	<.001†
U2rl (mm)	12.89 ± 2.28	13.10	13.97 ± 1.8	14.05	<.001†
U2v (mm^3)	382.68 ± 10	376.6	447.2 ± 153	400.0	<.001†
U2^ML (°)	17.84 ± 7.50	16.40	12.54 ± 5.6	11.40	<.001‡
U2^MOP (°)	93.13 ± 21.65	96.45	92.32 ± 21	91.40	NS
U3^U2 (°)	58.28 ± 46.67	45.10	12.13 ± 31	4.35	<.001†

†Wilcoxon's test; ‡Paired *t*-test.
NS, Not significant; SD, Standard deviation.

The angle between the maxillary lateral incisor and maxillary canine axis on the impacted side was higher than the non-impacted side ($P < .001$). The mean angles between the lateral axis and canine axis were 58.28° and 12.13° on the impacted and non-impacted sides, respectively.

DISCUSSION

In the current study, differences in the morphology and angular features of the maxillary lateral incisors were comparatively analyzed on 3D-reconstructed CBCT images between impacted and non-impacted sides, in cases presenting unilateral maxillary canine impaction. In order to make a reliable and reproducible comparison, we used CBCT images of unilateral impaction cases so that we could use the subjects as their own controls, and most importantly, eliminate inter-individual variability.[14] Using CBCT images provided many advantages, a few of which are mentioned below. The information collected from 3D radiography was significantly higher than that from traditional periapical and panoramic images.[15,16] CBCT provided extremely detailed 3D imaging and more beneficial views. Furthermore, superimpositions of images could be eliminated and the scanned anatomical structures, like the roots of teeth, could be reconstructed in different planes; this may enable the best treatment plan for the patient.[17] It is reported that only severe resorptions of roots can be predicted with panoramic images.[18] Therefore, the use of CBCT imaging may affect the absolute relevance of orthodontic treatment planning.

Patients were exposed to the high doses of radiation while obtaining medical CT scans. Although medical CT eliminates the disadvantages of 2D radiography, its clinical utility is limited because of the high radiation doses.[12] CBCT has an advantageous application in dentistry because it utilizes considerably lower radiation doses than medical CT.

Our findings demonstrated that all of the morphologic and angular characteristics of the lateral incisors, except for the angulation of the lateral incisor axis and the maxillary occlusal plane, were significantly different between the impacted and non-impacted sides. Currently, the 2 most popular theories reported in the literature are the lack of guidance (peg-shaped or missing),[19,20] and the genetic theory,[2,9] which both share the opinion that certain genetic characteristics associate with the impaction of the maxillary canine. Of the mechanisms proposed, the guidance theory has been observed as the most acceptable explanation, which proposes that the root of the maxillary lateral incisor has a critical role in the eruption of the maxillary canine. According to guidance theory, maxillary canine eruption would deviate if the maxillary lateral incisor's root function were impaired, indicating that it plays a key role in the normal eruption of the maxillary canine. Numerous researches in the literature have shown that anomalies in the maxillary lateral incisors have a significant association with maxillary canine impaction.[2,6,21] Moreover, an important decrease in the mesiodistal width of the maxillary teeth, including the maxillary incisors, had also been demonstrated in patients with maxillary canine impaction.[7,9]

On average, root length and total length of the lateral incisors adjacent to the impacted canines were smaller by 1.5 mm when compared to those on the non-impacted side. These findings are also in accordance with previous studies on lateral incisor lengths being shorter on the impacted side.[22-24] There was also a significant difference in the crown widths and volume of the lateral incisor between the 2 sides. These findings corroborate the previous findings on lateral incisor volume being smaller on the impacted side.[17,22,23] On the other hand, Kim et al.[24] did not find significant differences in any of the parameters regarding the crown of the maxillary lateral incisor.

The results of this study seem to indicate that shorter lengths and reduced volume of the maxillary lateral incisors affects impacted maxillary canines, as it can utilize a dominant local influence. According to guidance theory, these results can prove that smaller maxillary lateral incisors result in impaired eruption of the maxillary canine. It can be interpreted that patients with smaller crowns, roots, and reduced volumes of the maxillary lateral incisor are vulnerable to deviated eruption of the maxillary canine.

The present findings revealed significant differences between maxillary lateral incisors adjacent to impacted and non-impacted canines, in angulation with the adjacent maxillary canine and the midline. The midline angulation of the lateral incisor on the impacted side was lower than the on the non-impacted side, while Crincoli et al.[25] did not find a significant difference in lateral incisor axis and midline angulation between impacted and non-impacted sides. The explanation for our results can be that due to the maxillary impacted canine position, the axis of the adjacent lateral incisor might tend toward the midline and the lateral incisor adjacent to the impacted canine creates a narrower angle between the midline than the lateral incisor on the non-impacted side. Moreover, on the impacted side, the lateral incisor–canine axis angulation was significantly higher than that on the non-impacted side. Deckel et al.[8] found significant differences in mesiobuccal rotation and palatal root torque of lateral incisors between the impacted and non-impacted canine sides. When the maxillary canine fails to erupt, its axis might tend mesially or distally, and in both of these conditions, the lateral incisors on the impacted side compose a wider angle with the canine axis. Alqerban et al.[13] suggested that the angle between the impacted canine and the lateral incisor is a significant predictor of canine impaction. In mixed dentition, measurements of angle between the impacted canine and the teeth adjacent to canine using 3D images may prevent the resorption in adjacent teeth like lateral incisors. There are no significant differences between the 2 sides for the angulation of the lateral incisor axis and the maxillary occlusal plane.

In this study, the radiographic parameters of impacted maxillary canines associated with the adjacent lateral incisors were examined. The etiologic factors, such as the morphological and angular characteristics of lateral incisors, can be detected even at an early stage. Therefore, the present results may help orthodontists in the diagnosis, prevention, and planning of treatments for maxillary impacted canine.

The gubernacular canals that are thought to guide or direct the course of the erupting tooth may also be factors related impaction of teeth. Lower detection rates of gubernacular canals were observed in the maxillary lateral incisors, mandibular second premolars, and maxillary canines, and this could have resulted from the higher rate of accompanying eruption disturbances.[26] Therefore, in future studies, evaluation of the gubernacular canals and impaction of maxillary canines on CBCT images may also help predict the possible impaction of the maxillary canines.

This study was carried out in a retrospective design, which could be a limitation of this study. We would have preferred higher sample sizes. However, it was not possible to obtain more CBCT images because of the retrospective study design. Further studies are essential to evaluate angular and linear measurements within a larger sample size with CBCT images.

CONCLUSION

There are differences in lateral morphology and angular features between the impacted and non-impacted sides. The volume of the lateral incisor, mesiodistal and buccolingual widths of the lateral incisor crown, root and the total length of the lateral incisor, lateral incisor angulation to the midline and the adjacent canine, were strong predictors based on CBCT radiographs, and may assist orthodontists to identify the possibility of impaction.

Ethics Committee Approval: Ethical committee approval was received from the Ethics Committee of Başkent University (approval No: D-KA 19/21).

Informed Consent: Verbal informed consent was obtained from all participants who participated in this study.

Peer Review: Externally peer-reviewed.

Author Contributions: Concept - S.K., A.A.Ö., N.İ.T.; Design - S.K., A.A.Ö., N.İ.T.; Supervision - A.A.Ö., N.İ.T.; Materials - S.K.; Data Collection and Processing - S.K.; Analysis and Interpretation - S.K.; Literature Review - S.K.; Writing - S.K.; Critical Review - S.K., A.A.Ö., N.İ.T.

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Original Article

Reporting Sample Size Calculation in Randomized Clinical Trials Published in 4 Orthodontic Journals

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Main Points

- Inadequate sample size calculation includes the failure to report the confidence level, test power, effect size, and expected variability.
- Some parameters of sample calculations were more often reported in specific journals.
- RCTs published in orthodontic journals frequently do not adequately report the parameters used for sample calculations.

ABSTRACT

Objective: The purpose of this study was to describe sample size calculations in randomized clinical trials (RCTs) published in 4 orthodontic journals.

Methods: This cross-sectional study evaluated 142 RCTs published between 2015 and 2019 in the 4 journals with the highest impact factor in orthodontics according to the SCIMAGO 2018 ranking. In the study, 2 trained and experienced orthodontists assessed whether the RCTs evaluated reported their sample size calculations, and whether they adequately described the criteria for the calculations, including the level of significance, test power, precision or effect size (clinically relevant difference), and expected variability. The sample size calculation was considered adequately reported when the above 4 criteria were described.

Results: We identified 120 publications (84.5%) reporting the sample size calculation, but only 70 (58.3%) fully described the above parameters. Inadequate calculation included failure to report the confidence level (ranging from 0% to 12.9%), test power (ranging from 0% to 20%), effect size (ranging from 0% to 22.5%), and expected variability (ranging from 22.6% to 80%). According to the journal, some parameters of sample size calculation were more frequently reported.

Conclusions: RCTs published in the 4 leading orthodontic journals frequently do not report the parameters used for sample size calculations.

Keywords: Sample size calculations, randomized clinical trials, orthodontic journals

INTRODUCTION

Randomized clinical trials (RCTs) in orthodontic scientific literature are useful for answering clinical research questions through quasi-scientific experimentation and facilitating therapeutic decision making.[1-5] Correctly executed RCTs likely provide the best evidence on the results of health interventions.[1,6] Likewise, the ability to extrapolate the results of an RCT into different populations depends on the control of biases that may be present during trial.[7,8] Furthermore, every orthodontic researcher who designs an RCT expects to be able to extrapolate their results to clinical practice.[3,4] Therefore, in addition to randomization, one of the conditions that a study requires to be extrapolated is the use of adequate sample size to provide an adequately powered study.[1,7,9-11]

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The samples of RCTs should be representative of the study populations in which a clinically relevant effect is to be tested.[6,10,12] The representativeness of a sample is achieved by an adequate sample size determination and by the type of sampling used, which ideally, should be probabilistic.[13,14] The use of an appropriate sample size calculation is only the starting point for controlling the external validity of a study,[15-18] since while the use of a specific sample might be reported, the wrong assumptions regarding the parameters used during the sample size calculation may have been made.[12] Hence, it is important for the criteria used for the sample calculation to be clearly described in the materials and methods section of the articles to assess whether the calculations were properly estimated.[9,13,15,16] Moreover, sample size calculation in RCTs should have enough power to detect a clinically important difference, if present, or to confirm the lack of a difference between treatment groups. The investigators should conduct appropriate sample size calculations based on clinical importance and reasonable assumptions.[19,20]

When wrong parameters are introduced in the sample size calculation, they are frequently not related to the confidence level or test power considerations.[21,22] The problems in the case of a quantitative outcome variable begin with the decision of the expected effect size (precision), which is the minimum difference that is desired to be detected between the groups to be compared, or from a clinical point of view, the minimally significant difference to decide that one treatment is better than another. The second source of problems could be the estimated variability (standard deviation or variance).[11] Concerning a qualitative outcome variable, possible errors may be more related to poor decisions of the estimated differences in the proportions of the groups compared.[8,23]

Evidence-based dentistry describes RCTs as study designs that are near the top of the evidence pyramid, and these trials are usually the primary source for supporting the conclusions of systematic reviews answering therapeutic questions. Therefore, a good description of their sample calculations should be made to allow for adequate external validity.[5,6,15,16,18,24] Several studies have already evaluated sample size reporting in orthodontics and have highlighted that despite improvements, the quality of reporting sample size parameters remains suboptimal, and further studies are needed, especially in relation to RCTs.[25-28] Therefore, the purpose of this descriptive study was to determine the frequency of application and pertinence of sample size calculations of RCTs published from 2015 to 2019 in 4 leading orthodontic journals according to the 2018 SCIMAGO ranking.

METHODS

This cross-sectional study evaluated 142 RCTs published in 4 orthodontic specialty journals with a high-impact factor in orthodontics. The study was approved by the Ethics Committee of the Cientifica del Sur University (Lima-Perú) with protocol number 669-2019-POS8.

All the articles included were RCTs published from January 2015 to December 2019, in the 4 journals with the highest impact factor in the field of orthodontics according to the SCIMAGO 2018 journal ranking, https://www.scimagojr.com/journalrank.php?area=3500&category=3505 (accessed on April 25th, 2020). “Angle Orthodontist” (AO), “American Journal of Orthodontics and Dentofacial Orthopedics” (AJODO), “European Journal of Orthodontics” (EJO), and “Korean Journal of Orthodontics” (KJO).

The inclusion criteria were RCTs as defined by their authors in the title of their publications or in the methods section, and the inclusion of human samples. Animal trials, quasi-experiments, and observational and pilot studies (defined by the authors in the title) were excluded.

For the study, 2 orthodontists (MCA and LEAG) were trained in sample size calculation parameters and were calibrated during a pilot test including 30 RCT evaluations, obtaining Kappa intraobserver and interobserver agreements of 0.93 to 1 in both measurements for all the considered variables.

The evaluators then searched for articles that met the inclusion criteria in the selected journals. Once identified, we evaluated whether the authors performed a sample size calculation (to compare 2 means or to compare 2 proportions). This allowed verification of the articles that described sample calculations, and whether these defined the respective parameters including the confidence level (the measure of certainty regarding how exactly a sample reflects the population studied within a chosen confidence interval), test power (1-ß (type II errors)), effect size or precision (the difference desired to detect, referencing where these data were obtained) and the standard deviations or variances of the control groups (variability). Only the information reported in the publication was used.

A study was considered adequate when all of the 4 above parameters were reported; otherwise, the description was deemed inadequate. All the articles were evaluated twice by the 2 evaluators with an interval of 1 month between evaluations. In cases of discrepancies in the definition of any criterion, the consensus of the 2 evaluators defined whether or not the criterion was met.

Statistical Analyses

All the analyses were performed with the Statistical Package for Social Sciences (SPSS) Windows software, Version 24.0 (IBM SPSS Corp., Armonk, NY, USA). We described the reporting of sample size in all the journals, and then in each of the 4 journals evaluated. Mainly we evaluated whether the description of the sample calculations met the parameters required for sample size calculations. We assessed the criteria fulfilled, the number of criteria fulfilled, the orthodontic journal, and the year of publication.

RESULTS

One hundred forty-two RCTs were identified in the 4 journals evaluated, 120 of which (84.5%) reported the sample calculation. Sample calculation was described in > 80% of the articles in

Table 1. Evaluation of the parameters reported for sample size calculation

	AO = 49		AJODO = 35		EJO = 52		KJO = 6		Total = 142	
	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
Parameter	*n* (%)	*n* (%)	*n* (%)	*n* (%)	*n* (%)	*n* (%)	*n* (%)	*n* (%)	*n* (%)	*n* (%)
Description of a sample calculation	40 (81.6)	9 (18.4)	31 (88.6)	4 (11.4)	44 (84.6)	8 (15.4)	5 (83.3)	1 (16.7)	120 (84.5)	22 (15.5)
Description of specific reports	AO = 40		AJODO = 31		EJO = 44		KJO = 5		Total = 120	
	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
	n (%)	*n* (%)	*n* (%)	*n* (%)	*n* (%)	*n* (%)	*n* (%)	*n* (%)	*n* (%)	*n* (%)
Confidence level (%)	37 (92.5)	3 (7.5)	27(87.1)	4 (12.9)	41 (93.2)	3 (6.8)	5 (100.0)	0 (0.0)	110 (91.7)	10 (8.3)
Test Power	38 (95.0)	2 (5.0)	31 (100.0)	0 (0.0)	44 (100.0)	0 (0.0)	4 (80.0)	1 (20.0)	117 (97.5)	3 (2.5)
Effect size	31 (77.5)	9 (22.5)	31 (100.0)	0 (0.0)	35 (79.5)	9 (20.5)	4 (80.0)	1 (20.0)	101 (84.2)	19 (15.8)
Variability	18 (45.0)	22 (55.0)	24 (77.4)	7 (22.6)	28 (63.6)	16 (36.4)	1 (20.0)	4 (80.0)	71 (59.2)	49 (40.8)

AO, Angle Orthodontist; AJODO, American Journal of Orthodontics and Dentofacial Orthopedics; EJO, European Journal of Orthodontics; KJO, Korean Journal of Orthodontics.

the 4 journals. The criteria for sample calculation most frequently described in the 4 journals (> 90%) were the power of the test (97.5%) and the confidence level (91.7%) (Table 1).

When we evaluated the use of the 4 parameters for describing sample calculations in the 4 journals, only 70 (58.3%) studies described all the parameters, and 30 (25%) reported using at least 3 parameters. The 4 sample calculation parameters were most frequently reported in the journals AJODO and EJO (Table 2).

When evaluating adequate description of the sample calculation, it was observed that 10 (8.3%) studies did not describe the confidence level, the test power was not specified in 3 (2.5%), the effect size was not specified in 19 (15.8%), and the expected variability was not described in 49 (40.8%) studies.

The test power was described in 100% of the articles in AJODO and EJO, and in 95% of the articles in AO. Furthermore, a description of effect size was more frequent in AJODO (100%), EJO (77.5%), and AO (79.5%).

Table 2. Number of parameters reported during sample size calculation in the journals evaluated

Number of Parameters Reported	AO	AJODO	EJO	KJO	Total = 122 (100%)
	n (%)	*n* (%)	*n* (%)	*n* (%)	*n* (%)
4	17 (42.5)	23 (74.2)	29 (65.9)	1 (20.0)	70 (58.3)
3	13 (32.5)	8 (25.8)	6 (13.6)	3 (60.0)	30 (25.0)
2	9 (22.5)	0 (0.0)	9 (20.5)	1 (20.0)	19 (15.8)
1	1 (2.5)	0 (0.0)	0 (0.0)	0 (0.0)	1 (0.8)

AO, Angle Orthodontist; AJODO, American Journal of Orthodontics and Dentofacial Orthopedics; EJO, European Journal of Orthodontics; KJO, Korean Journal of Orthodontics.

The expected variability was more frequently reported in the AJODO (77.4%) and in EJO articles (63.6%) (Table 1).

Full reporting of sample size calculations was observed with 2 of the 4 journals, AJODO (74.2%) and EJO (63.6%), and was similar regarding the year of publication (Table 3).

Additionally, only 9 (7.5%) studies used a previous pilot test to perform the sample calculation, while 38 (31.7%) did not describe how the precision/effect size of their calculation was determined. Finally, among the articles performing sample size calculation, 96 (80%) exceeded the minimum sample size required, mainly in 3 of the journals evaluated (AJODO, EJO, KJO) (Table 4).

Table 3. Efficiency of sample calculation reporting (reported 4 parameters) according to the type of journal and the year of publication

Journal	Efficient Reporting, *n* (%)	Without Efficient Reporting, *n* (%)	Total, *n* (%)
AO	17 (42.5)	23 (57.5)	40 (100)
AJODO	23 (74.2)	8 (25.8)	31 (100)
EJO	29 (65.9)	15 (34.1)	44 (100)
KJO	1 (20.0)	4 (80.0)	5 (100)
All Journals	70 (58.3)	50 (41.7)	120 (100)
Year of publication			
2015	14 (77.8)	4 (22.2)	18 (100)
2016	14 (58.3)	10 (41.7)	24 (100)
2017	10 (62.5)	6 (37.5)	16 (100)
2018	14 (50.0)	14 (50.0)	28 (100)
2019	17 (50.0)	17 (50.0)	34 (100)

AO, Angle Orthodontist; AJODO, American Journal of Orthodontics and Dentofacial Orthopedics; EJO, European Journal of Orthodontics; KJO, Korean Journal of Orthodontics.

Table 4. Description of other specific parameters reported during sample size calculation

	AO	AJODO	EJO	KJO	Total = 122 (100%)
Other Specific Parameters Evaluated	*n* (%)	*n* (%)	*n* (%)	*n* (%)	*n* (%)
Details of obtaining the effect size					
Not precise	19 (47.5)	4 (12.9)	14 (31.8)	1(20.0)	38 (31.7)
Previous pilot test	2 (5.0)	4 (12.9)	3 (6.8)	0 (0.0)	9 (7.5)
Obtained from literature	19 (47.5)	23 (74.2)	27 (61.4)	4 (80.0)	73 (60.8)
Exceeded the minimum sample size calculated					
Yes	26 (65.0)	26 (83.9)	39 (86.9)	5 (100.0)	96 (80.0)
No	14 (35.0)	5 (16.1)	5 (11.4)	0 (0.0)	24 (20.0)

AO, Angle Orthodontist; AJODO, American Journal of Orthodontics and Dentofacial Orthopedics; EJO, European Journal of Orthodontics; KJO, Korean Journal of Orthodontics.

DISCUSSION

A description of the calculation of sample size is necessary in scientific studies in order to determine that a representative number of individuals from a related potential population is included in the study.[6,10,12] Ideally, studies should evaluate the entire study population, but due to financial reasons and time limits, this rarely happens. A large number of investigations use unrepresentative samples and mistakenly seek to extrapolate their results to their study population.[25] To achieve external validity of the results, the study must have sample representativeness that is first related to the calculation of the sample size; and, second, to the type of sampling that should be a probabilistic, ensuring that all individuals in a study population have the same probability of being chosen for the study.[6,10-14] Thus, errors in the calculation of sample size may be widespread due to a lack of knowledge of the methodological importance of this calculation, which consequently affects the representativeness of the samples and thereby decreases the real value of the study.[12,17] In the studies in which a sample size calculation was provided, it was noted that the determination of effect size (the clinically relevant difference between groups) or variability (the amount of data dispersion in the groups) raised the greatest difficulties. These 2 parameters are the main criteria for calculating sample size, since the selection of inaccurate precision or variability in sample calculation will likely increase or decrease the *P* value, precluding the identification of significant differences between the groups compared or even oversizing the study groups.

Currently, RCTs are considered the best study design to address therapeutic clinical questions. It is important to note that for the present study, in addition to RCT being included in the title or the methods section of the studies evaluated, we confirmed compliance to this condition in the papers analyzed to avoid any type of bias. It is important for RCTs to comply with reporting representative samples.[29,30] We therefore determined the frequency of application and the pertinence of sample size calculation in RCTs published from 2015 to 2019 in the 4 journals with the highest orthodontic impact factor according to the SCIMAGO 2018 ranking.

Few studies in other areas of dentistry have evaluated whether sample size calculations of RCTs were adequately developed.[29-32] A review of 42 RCTs in prosthodontics published between 2008 and 2017 in the leading prosthodontic journals concluded that 50% of the publications did not adequately describe the calculation of their sample sizes.[31] Likewise, in endodontics, a review of 50 RCTs published in the 2 high-impact journals in this field from 2000 to 2001 and 2009 to 2010 concluded that 60% of the studies did not indicate how the sample sizes were determined. Although detailed reporting significantly improved between 2000 and 2010,[29] these results were still not encouraging. To the best of our knowledge, only a few related studies were conducted in orthodontics in 2011,[26] 2014,[27] and more recently in 2019,[28] but did not consider only RCTs. This first study[26] evaluated the frequency of reporting sample size calculation in studies published in journals in Brazil and the United States. The authors suggested that the researchers and the editorial committee of these journals should be more concerned about errors related to the use of an inappropriate sample size. The second study[27] concluded that although sample size calculations are often reported in trials published as RCTs in orthodontic specialty journals, reporting is usually suboptimal and in need of significant improvement. Nonetheless, this trend has yet to be addressed, with more than 40% of RCTs presenting deficiencies in the reporting of sample size calculation.

Our study evaluated 142 RCTs published from 2015 to 2019 in the 4 major orthodontic journals according to the SCIMAGO 2018 ranking, which is highly recognized in the academic field. We found that although 84.5% of these publications reported the use of sample size calculations, only 58.3% of the publications complied with the description of the 4 criteria for sample size calculation: confidence level, test power, effect size or precision, and variability of the results. It is important to note that the confidence level used in all the RCTs evaluated was 95%, with most reporting a test power of 80% or 90%. It is clear that a variation in these values may increase or decrease the sample size, and consequently, the possibility of obtaining a representative sample. Moreover, it is necessary for this information to be adequately described for good understanding of sample size calculation, analysis of external validity, and finally to guide new RCTs.

In a previous study comparing the percentages of reporting sample calculations (2005 and 2008), only 3% of the studies in Brazilian journals and 21% in American journals described this calculation.[26] According to our findings, these results have considerably increased (84.5%). This information indicates that despite the increase in the description of sample size calculations between 2008 and 2019 in the orthodontic journals evaluated, sample size calculations are still under-reported. It should also be noted that the descriptions assessed were not the same in all the journals.

As mentioned above, the actual external validity was questionable in almost all of the published RCTs. Even in the case of split-mouth designs, accurate description of the parameters used for sample size calculation should be included and described in the method section of scientific articles, but this does not always occur. Furthermore, it is important to specify that the sample calculation achieves a minimum required sample size, considering that a larger number should be included in order to obtain an adequate final power for the study due to possible sample loss to follow-up. All of these aspects should be taken into account by all orthodontic journal editors in order to ensure and increase the external validity of the RCTs published.[29,32,33,34]

The main purpose of this study was not to compare the criteria of different orthodontic journals for calculating the sample size of RCTs but rather to describe how many clinical trials meet the requirements of good sample calculation according to the most representative parameters reported in the scientific literature. This is important in order to promote the practice of better sample calculations in RCTs, regardless of the type of journal.

We found that only a little more than half (58.3%) of the studies in the 4 journals evaluated complied with the 4 parameters for sample size calculation, with 25% fulfilling 3 parameters. Full reporting of sample size calculations was performed in AJODO (74.2%) and EJO (63.6%), but it was not related to the year of publication.

It should be noted that of the 142 RCTs selected, all included a quantitative outcome variable, and therefore, only specific sample size characteristics to compare 2 means were evaluated. It was observed that a low percentage of publications did not report the confidence level, although it is the most straightforward criterion to report. On the other hand, while not reported in all the publications, the power of the sample size power was described in 100% of the articles in AJODO and EJO, and in 95% of the articles in AO. Likewise, the confidence level was the second most frequently described criterion (> 91%) in all orthodontic journals.

Moreover, the effect size (clinically relevant difference) was not reported in 15.8% of the included RCTs. It is essential to specify and quantify the effect size for reviewers and readers to know whether the reported difference is clinically relevant and how the effect size was calculated.[25] In the RCTs published in AJODO, EJO, and AO, the effect sizes were 100%, 77.5% and 79.5%, respectively. While many studies reported effect size values that were thereafter not considered when discussing their study results, these values should have been used as the clinical relevance threshold. In addition, these results are sometimes not related to an actual clinically relevant difference but are presented in the article as if they really were. Future studies should take into account the effect size in terms of small, medium, or large clinical impact. Likewise, almost half of the publications did not describe the expected variability for their sample calculations (40.8%), and therefore, the amount of data dispersion these publications expected remained unknown. In this regard, this criterion was best described in RCTs published in AJODO and EJO (77.4% and 63.6%, respectively) compared to the studies in the other 2 journals.

In the evaluation of precision in sample size calculation, 60.8% of the studies obtained this parameter from the scientific literature, while only 7.5% obtained the study precision from a previous pilot test, and 31.7% did not report sample precision, despite it being an important parameter to consider in sample calculations.

On the other hand, it is important to note that the majority of the publications evaluated (80%) exceeded the minimum sample size required by their sample calculations, mainly in 3 of the journals assessed (AJODO, EJO, KJO), being an excellent methodological finding that should be noted.

In summary, despite the large number of RCTs published in the field of orthodontics reporting the use of sample size calculation, there are still deficiencies in describing the method of sample size determination, leading to uncertainty regarding the external validity of the results. Effective, in-depth descriptions of sample size calculations should be provided in future publications to improve the extrapolation of the results reported to clinical scenarios.

One limitation of this study was that it only analyzed a specific aspect of the development of an RCT, and it is clear that the methodological quality of RCTs also involves many other aspects. We focused on sample calculation since it is associated with the representativeness of a sample and the possibility of achieving greater external validity. Additionally, other important aspects can influence the calculation of sample size. These include, among others, the necessary information to fulfill the sample size formulas, whether derived from a pilot study or not, the statistical analysis to obtain the data to be introduced in the formulas, and the number of study groups, especially when there are more than 2 groups and a specific group is required. However, we only analyzed the main factors involved in sample calculation based on the main reports of the scientific literature. Nevertheless, more studies considering these different points of analysis are needed.

CONCLUSION

Adequate description of sample size calculation in RCTs published in 4 leading orthodontic journals is largely deficient, and that should be taken into account in future publications to improve the quality of orthodontic RCTs.

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Original Article

Effects of Type and Amount of Orthodontic Tooth Movement on Digital Model Superimposition Accuracy

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Main Points

- Digital model superimposition (DMS) is a novel technique used to evaluate orthodontic tooth movements.
- There is not enough information in the literature regarding the most reliable algorithm to use in DMS.
- The performance of the local best-fit (LBF) algorithm was independent of the type and degree of movement of the teeth.
- Landmark-based (LB) algorithm success was negatively affected by the degree of tooth movement.
- From a clinical standpoint, however, both algorithms were very accurate, regardless of the degree of movement of the teeth and the type of movement.

ABSTRACT

Objective: To assess the impact of the type or degree of tooth movement on the success of 3D model superimposition using 2 different algorithms.

Methods: The sample consisted of pre-treatment digital maxillary models of 40 patients. Eight different groups were created by applying 8 different virtual setups (VS) to each model. Teeth crowns were moved by 1 mm or 2 mm in different directions (sagittal, transversal, vertical, combination) using the Ortho Analyzer software. Each model obtained from the VS was overlapped with the original model using the landmark-based (LB) and local best-fit (LBF) algorithms. In the post-superimposition assessment, the area of the palate vault which was not affected by teeth movements was selected. Both groups and algorithms were compared using the numeric data of root mean square (RMS) and percentage of perfectly matched areas (PMA). In addition, the displacement of the right canine (RC) was measured after superimposition. The comparison of the superposition outcomes among the groups was evaluated with one-way ANOVA and Kruskal–Wallis tests. The Student's *t*-test was used to compare the two algorithms.

Results: Both the algorithms were not affected by the type of tooth movement. However, the increase in the amount of tooth movement negatively affected the performance of the LB algorithm. LBF achieved the model superimpositions more effectively and faster than LB. No difference was found in RC measurements between the LB and LBF algorithms.

Conclusion: The results indicate that LBF offers more sensitive and successful 3D model superimposition. The performance of the LB algorithm was, however, acceptable for analysis of 3D tooth movement.

Keywords: Intraoral scanner, digital model superimposition, virtual setup

INTRODUCTION

Three-dimensional intraoral scanners are one of the most exciting inventions in general dentistry and orthodontics.[1] This evolutionary technology has enabled a wide range of innovations such as digital model analysis, virtual setup (VS), and customized appliance design.[2-4] By VS application, the crowns of the teeth can be moved digitally in the desired direction and to the desired degree.[5] Nowadays, VS is essential for the preparation of lingual bracket jigs and clear aligner production. In addition, VS can be used to visualize treatment objectives and to evaluate the quality of treatment outcomes.

The initial and final digital models are compared with the 3D superimposition technique for the assessment of treatment results. This superimposition enables an orthodontist to analyze 3D tooth crown movements.

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Before 3D digital modeling, movements of the teeth were evaluated with a number of measurements on the plaster model or via cephalometric superimpositions.[6-8] However, landmark identification errors could be seen in the cephalometric superimpositions, due to overlapping images of bilateral anatomical structures and teeth.[9,10] The assessment of teeth movement may also be adversely affected by factors such as magnification,[11] craniofacial growth during prolonged treatment,[12] type of reference planes used in the cephalometric superimpositions,[13] and wrong head position.[14] In addition, the 2D tooth movement is evaluated on a stable cephalometric image, while the model can be rotated in 3 directions of space during DMS so that more accurate and valid measurements can be carried out at the appropriate angle.

In 3D teeth movement analysis, digital models are superimposed using anatomical landmarks which can remain stable during orthodontic treatment.[15] Palatal rugae are used to identify stable anatomical landmarks on the palatal surface of the patient. However, due to orthodontic treatment, dimensional or positional changes in the pattern of palatal rugae may occur.[16] While the stability of rugae is widely disputed, there is consensus in the literature on the stability of the third rugae.[17-21] LB superimposition may not be reliable, because the stability of the palatal rugae is questionable. But could models be overlapped with another algorithm without the use of palatal rugae? A good alternative to the LB approach is the LBF algorithm. The basic working mechanism of the LBF algorithm is that digital models are overlapped by achieving maximum surface contact.

Evaluation of tooth displacement via DMS is considered a reliable method.[22] However, it is not known which factors affect the success of both the LB algorithm and the local best-fit algorithms, and which method is more reliable and valid. We noted in our review that the literature on this subject does not contain adequate and satisfactory information.

The aim of the study was to assess the correlation between the dental movements (type and amount) and the accuracy of DMS, and to test the reliability of the 2 algorithms.

METHODS

Definition of the Groups

The experimental protocols of this study were approved by the Clinical Research Ethics Committee of Afyonkarahisar Health Science University. Forty different upper digital models were selected from our archive for the study. 3Shape TRIOS (Copenhagen, Denmark) had been used for the model acquisition. Accurately scanned models, particularly in the palatal area, were included in the study. Patients with missing teeth, partially erupted teeth, or decayed teeth in the maxilla were excluded. Informed consent forms were obtained from all the patients included in the study. First, each model was segmented; the segmented teeth then were moved virtually in 8 different variations. A total of 320 new digital models were divided into 8 groups: Group 1: 1 mm sagittal movement of all teeth (S1), Group 2: 1 mm transversal movement of the posterior teeth (canine to the second molar) (T1), Group 3: 1 mm vertical movement (extrusion) of all teeth (V1), Group 4: Combination of all 1-mm tooth movements (C1 = S1+T1+V1), Group 5: 2 mm sagittal movement of all teeth (S2), Group 6: 2 mm transversal movement of the posterior teeth (canine to the second molar) (T2), Group 7: 2 mm vertical movement (extrusion) of all teeth (V2), Group 8: Combination of all 2-mm tooth movements (C2 = S2+T2+V2).

Digital Model Segmentation and Virtual Teeth Movements

Ortho Analyzer software (Copenhagen, Denmark) was used at this stage of the study. The workflow that guides the virtual segmentation (dividing teeth into a separate 3D object) of teeth crowns was as follows (Figure 1):

- Setpoints: selecting the mesial and distal ending of each tooth.
- Define cut: the software automatically cut the marginal line of each tooth. The accuracy of all marginal lines was double-checked. In case of need, they were edited in accurate form.
- Sculpt: initialization of the segmentation. The accuracy of each segmentation was controlled, and if necessary, the previous steps were renewed.

After the segmentation, each tooth was individually moved in a certain direction and to a degree in accordance with the group definitions. All individual tooth movements were reviewed in a chart, and the new form of each digital model was saved and exported in STL format after ensuring that the defined tooth movement was achieved.

Superimposition of the Digital Models

The non-segmented original version of the models was used as a reference in the superimpositions. The reference models were overlapped individually with each model of the experimental groups using the Geomagic Control X (Geomagic; Morrisville, USA) software. Two different algorithms were preferred in the DMSs: LB and LBF. Four points were marked on the third rugae for the LB superimposition (Figure 2). LBF (i.e., the search for maximally perfectly matched areas between 2 models) overlapped the models automatically without needing a point marking. After the superimpositions, the horizontal reference plane was positioned 2-3 mm below the apical gingival margin, and all overlapping surfaces, except the palatal roof, were removed. Only surface deviations on the roof of the palate were evaluated, because in an ideal and accurate overlap, there should be no surface deviation in this region. In other words, the area should be completely green (perfectly aligned areas) after overlapping. The reason why the reference plane was placed 2-3 mm below the apical gingival margins was that the software was unable to precisely mimic the movement of soft tissue during the tooth crown movement (Figure 3).

Three-dimensional surface deviations were shown with color-coded maps. The color codes had the following meanings: green: perfectly aligned areas, red; positively positioned areas relative to the reference model, and blue; negatively positioned areas. Ideally, the algorithms should overlap the upper digital models

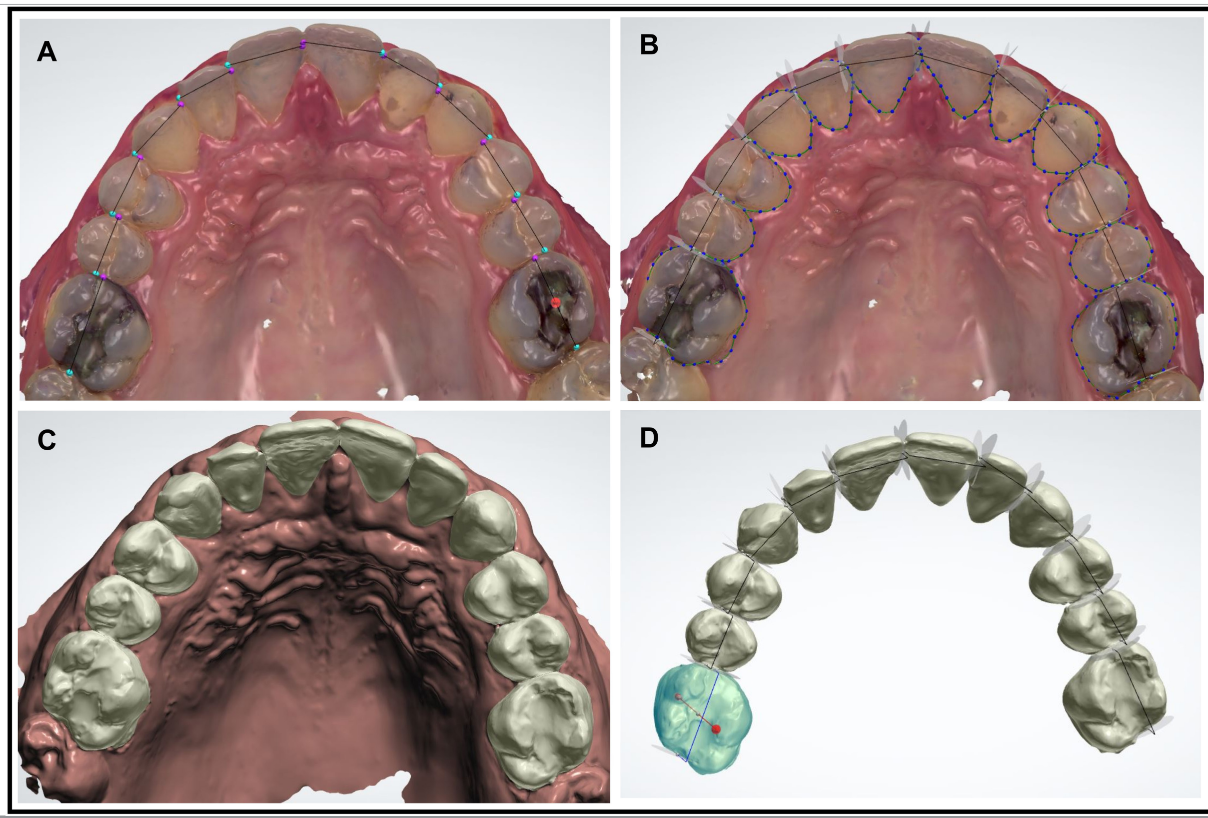

Figure 1. A-D. The workflow that guides the virtual segmentation. (A) Marking the teeth's mesial and distal points; (B) Automatic determination of marginal boundaries; (C) Segmentation of each tooth; and (D) Illustration of segmented teeth.

on the palatal roof region that are not affected by tooth movements, and no surface deviation should be seen on the palate roof. Therefore, to test the performance of the 2 algorithms, only the palatal roof was selected and only the surface deviations in this region were assessed (Figure 4). The following numerical surface deviation data, which were calculated automatically by the software, were used to compare the groups with statistical analysis: RMS (the square root of the arithmetic mean of the squares of

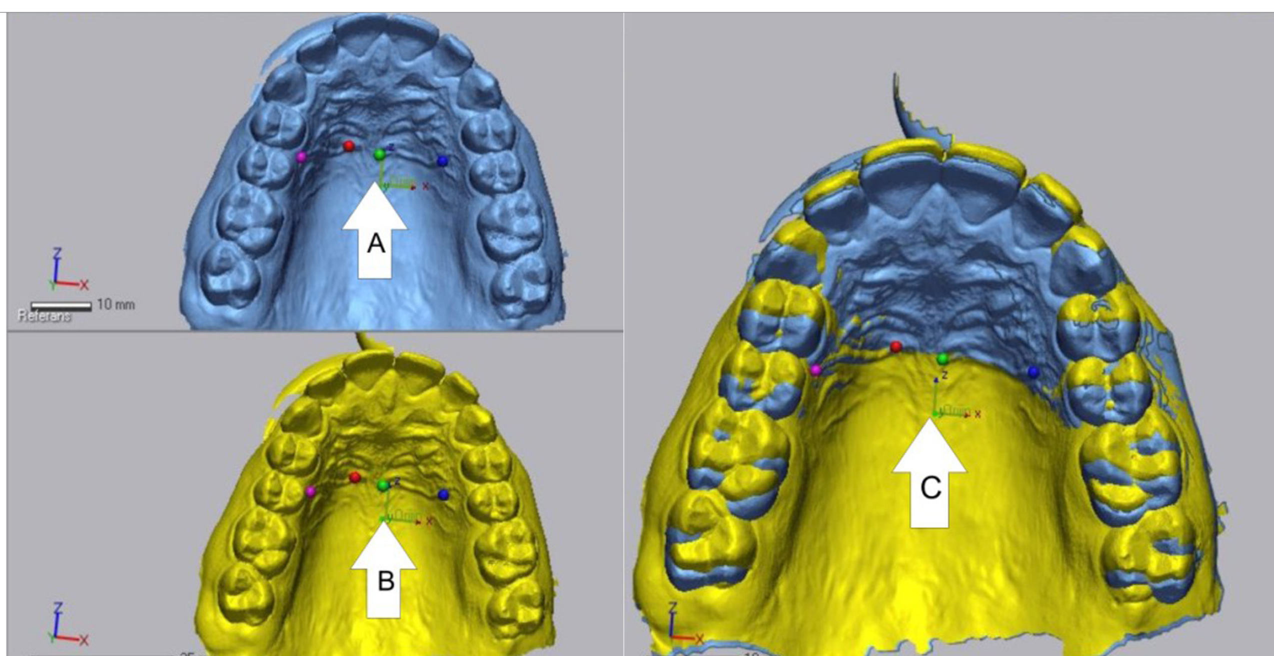

Figure 2. The point marking for the LB method. (A) Pre-setup model; (B) Post-setup model; (C) Superimposition of the 2 models. Pink dot: lateral tip of the right third ruga, red dot: medial tip of the right third ruga, green dot: medial tip of the left third ruga, and blue dot: lateral tip of the left third ruga.

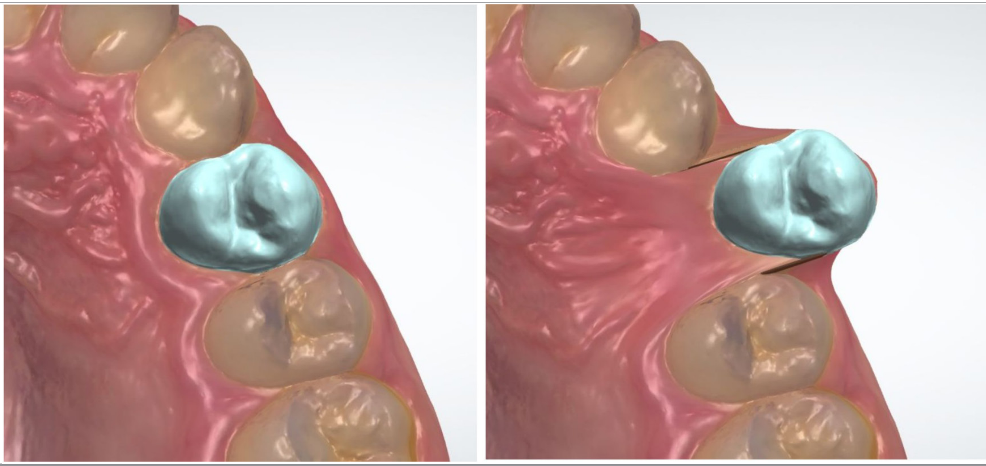

Figure 3. Illustration of poor imitation of soft tissue movements during the crown movements.

the point-to-point distance between the areas with an identical coordinate system) and PMA (the ratio of the perfectly matched area to the total area). In addition, the right canine (RC) displacement was calculated to test how accurately the 1 mm or 2 mm of crown movement was measured using the digital superimposition technique.

Statistical Analysis

The Statistical Package for Social Sciences (SPSS) 22.0 package program (IBM SPSS Corp., Armonk, NY, USA) was used to calculate the mean values and standard deviations of each parameter. For certain parameters, one-way ANOVA and post hoc Tukey tests were performed to compare the data between the groups, and the Kruskal–Wallis and post hoc Tamhane tests were used for some non-homogeneous data.

Student's *t*-test and Mann-Whitney U test were used to compare the results of LB and LBF algorithms. RC measurements were repeated 10 days later by the same researcher to detect the intra-examiner error rate (F.S). Repeated measurements were compared with the intraclass correlation coefficient (ICC) test. Similarly, 10 randomly selected patient models were superimposed for the second time to test the repeatability of the LB technique and the results were compared with the ICC test.

RESULTS

Comparison by Type of Tooth Movement Assessment of 1-mm Displacements

The mean percentage of the perfectly matching area (PMA) of all groups (S1, T1, V1, and C1) was 99.6% for LBF and 73.6% for

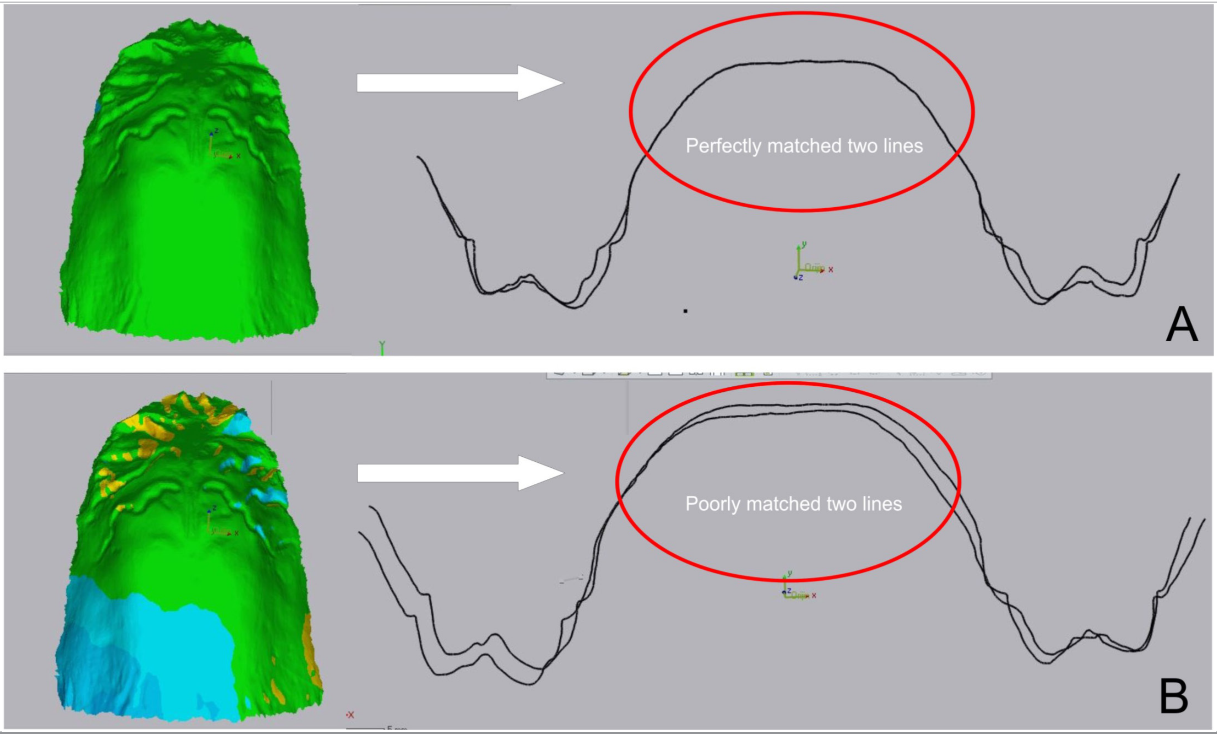

Figure 4. A, B. (A) Illustration of the LBF algorithm results; (B) Illustration of the LB algorithm results. Color distribution in the palate was expressed as PMA value. RMS meant the distance between the 2 poorly matched lines.

Table 1. Comparison of PMA values between LB and LBF

	LB	LBF	
	PMA	PMA	*P*
S1	74.82 ± 19.4[a]	99.61 ± 0.5[a]	
T1	72.18 ± 17.2[a]	99.68 ± 0.3[a]	
V1	72.39 ± 19.3[a]	99.52 ± 0.5[a]	
C1	75.20 ± 19.2[a]	99.77 ± 0.2[a]	
Total 1	73.65 ± 18.7[A]	99.65 ± 0.4[A]	.80
S2	65.02 ± 24.9[b]	99.03 ± 1.0[a]	
T2	66.59 ± 22.9[b]	99.34 ± 0.6[a]	
V2	70.52 ± 27.1[b]	98.93 ± 1.0[a]	
C2	62.01 ± 24.7[b]	99.53 ± 0.5[a]	
Total 2	66.03 ± 24.9[A]	99.21 ± 0.8[B]	.001
	P < .001	*P* > .05	

[a,b]Statistically significant difference between the columns, [A,B]Statistically significant difference between the lines.
LB, landmark based; LBF, local best-fit; PMA, perfectly matching area; S1, sagittal 1 mm; T1, transversal 1 mm; V1, vertical 1 mm; C1, combination 1 mm; S2, sagittal 2 mm; T2, transversal 2 mm; V2, vertical 2 mm; C2, combination 2 mm

LB. This difference between the 2 methods was statistically significant. The RMS value in the LBF group (1.1 µ) was quite small compared to the LB group (9.5 µ) ($P < .001$) (Tables 1 and 2).

When the performance of the 2 algorithms was statistically compared in terms of the type of tooth movement, it was observed that neither the LB nor the LBF algorithm was affected by the type of tooth movement.

Comparison by Type of Tooth Movement Assessment of 2-mm Displacements

The average PMA of the 4 groups in the LBF superimpositions was 99.2%. The mean value of RMS in the LBF group was 1.8 µ.

Table 2. Comparison of RMS values between LB and LBF (One-way ANOVA and Kruskal-Wallis tests)

	LB	LBF	
	RMS	RMS	*P*
S1	9.5 ± 5.2[a]	1.2 ± 0.7[a]	
T1	9.7 ± 3.9[a]	0.9 ± 0.5[a]	
V1	9.9 ± 5.3[a]	1.2 ± 0.6[a]	
C1	8.9 ± 4.4[a]	0.9 ± 0.4[a]	
Total 1	9.5 ± 4.7[A]	1.1 ± 0.6[B]	.001
S2	12.7 ± 7.9[b]	2.1 ± 1.5[a]	
T2	11.7 ± 8.2[b]	1.7 ± 0.9[a]	
V2	11.4 ± 9.4[b]	2.0 ± 1.2[a]	
C2	14.2 ± 9.6[b]	1.4 ± 0.6[a]	
Total 2	12.5 ± 8.8[A]	1.8 ± 1.2[B]	.001
	P < .5	*P* > .05	

[a,b]Statistically significant difference between the columns, [A,B]Statistically significant difference between the lines.
LB, landmark based; LBF, local best-fit; ,RMS, Root mean square; S1, sagittal 1 mm; T1, transversal 1 mm; V1, vertical 1 mm; C1, combination 1 mm; S2, sagittal 2 mm; T2, transversal 2 mm; V2, vertical 2 mm; C2, combination 2 mm.

No significant differences were observed in the comparison of PMA and RMS parameters among the groups (S2, T2, V2, and C2) ($P > .05$) (Table 1).

The average PMA of the 4 groups in the LB superimpositions was 66.0%. The mean value of RMS in the LB group was 12.5 µ (Table 2). There was no statistically significant difference in RMS and PMA values between the groups. When comparing the efficiency of LBF and LB algorithms using RMS and PMA values, it was found that the effectiveness of the LBF technique was greater.

Effect of Degree of Movement 1 mm vs 2 mm

In LB superimpositions, the PMA value was 73.6% for 1-mm displacements and 66.0% for 2-mm displacements. The difference was statistically significant, in other words, the LB algorithm was affected by the amount of movement of the teeth.

The LBF algorithm's PMA value for 1-mm displacement was 99.6% and 99.2% for 2-mm displacement. This small difference (0.4%) was not statistically significant ($P = .135$). In RMS, another parameter that demonstrates the success of the LBF algorithm, there was no significant difference between 1 mm and 2 mm of displacement ($P = .147$).

Results ot Right Canine Measurements

The success of the LB and LBF algorithms allowed the 1-mm or 2-mm tooth movements obtained in the VS to be measured as very close to the original (Table 3). No statistically significant differences were observed between groups in the RC measurements. The intraclass correlation coefficient results performed to test the accuracy of the RC and LB data are shown in Table 4.

DISCUSSION

DMS is a practical method for 3D visual and quantitative analysis of changes that occur with orthodontic treatment or growth

Table 3. Comparison of RC measurements between LB and LBF

	LBF	LB	
Groups	Mean ± SDs	Mean ± SDs	*P*
S1	0.99 ± 0.03	0.97 ± 0.3	787
T1	0.98 ± 0.03	1.05 ± 0.2	693
V1	0.96 ± 0.02	1.04 ± 0.2	834
S2	2.01 ± 0.09	2.02 ± 0.3	901
T2	1.99 ± 0.07	2.09 ± 0.2	854
V2	1.97 ± 0.05	2.09 ± 0.3	729

($P > .05$).
SD, standard deviation; S1, sagittal 1 mm; T1, transversal 1 mm; V1, vertical 1 mm; S2, sagittal 2 mm; T2, transversal 2 mm; V2, vertical 2 mm.

Table 4. Intraclass correlation coefficient (ICCs) results

	PMA	RMS	RC
ICCs	0.968	0.974	1.00

PMA and RMS value belong to the LB algorithm.

and development. There are a variety of software packages used to superimpose the initial and final models, and they use a wide range of algorithms.[23] Overlaps can be made by selecting points (LB) or areas (surface-based) in the palatal region.[24,25] The combination of point selection and area selection is also an option.[26] A number of researchers have conducted studies to test the accuracy of these methods.[18,27,28] Talaat et al. [25] reported that the LB algorithm is reliable, valid, and reproducible for the 3D model superimposition. However, there is no standard for determining the number and location of points when using the LB algorithm.

The selection of different areas of the palate (in terms of size and location) has been shown to influence the results of surface-based (SB) superimpositions.[24] The LBF algorithm, on the other hand, is a fast and practical method that superimposes models without the need for field or point selection.[29] However, there is insufficient data on the reliability of the LBF algorithm and its superiority or deficiency over other methods. To our knowledge, this research was the first study to assess whether the algorithms used in model superimpositions are affected by the degree and type of tooth movement.

During the orthodontic treatment of growing patients, the reference points or areas used for model superimposition change depending on the development of the maxilla. Rugae are unique to individuals, like fingerprints, and provide repeatability in dot positioning.[30] Rugae may exhibit dimensional or positional changes at the end of treatment due to growth and development. Researchers have suggested that the longitudinal model analysis of the medial ruga area, similar to the third ruga, could be used as a stable reference area.[17] Maxillary expansion is another factor that affects the stability of the rugae, and its impact on the rugae is still controversial.[31,32]

Both the LB and SB methods are time-consuming and computing-intensive. However, the LBF algorithm is very simple and practical to use. Only the 2 models for overlap need to be selected. The LBF procedure is more accurate than other methods because the algorithm continues to work with complex computer calculations until the deviation between the surfaces is minimized and maximum surface matching is achieved.[33] The success of LB is correlated with the number of points marked or their position. So, does LBF provide a strong alternative to LB?

Our findings showed that the PMA value for LBF was 99%, which indicated the high success of LBF. Additionally, neither the type of tooth movement nor the degree of it influenced the performance of the LBF algorithm. The average RMS value in the LBF group (1-2 μ), which shows the distance of the surface deviation between the 2 models, revealed how accurate the algorithm was. Although the LB algorithm was not affected by the movement type, the performance of the algorithm decreased from 73.6% to 66.0% as the amount of displacement increased. However, we believe that the sensitivity of measuring tooth movement after superimposition was related to the RMS value, rather than to the PMA. The primary factor that could affect RC measurements was the RMS value that indicates the distance between matching surfaces. RC measurements were not affected as the RMS was as small as 1-2 μ for LBF and 9-12 μ for LB. The smaller the RMS value, the greater the possibility of identifying the more exact tooth movements. Although the RMS value showed a statistically significant difference between LB and LBF, this difference at the micron level did not affect the accuracy of the RC measurements. This was evidence of the precise identification of the points by the operator and the efficient use of the LB technique. By measuring the displacement of the palatal ruga points and the central incisor movement, Jang et al.[18] compared the LB algorithm to the miniscrew-assisted superimposition method and reported no difference between the 2 methods. According to Talaat et al.,[15] 3D LB digital dental model superimposition using 3 reference points marked along the mid-palatal raphe was a valid and reliable technique. Choi et al.[27] emphasized that using the palatal surface provides reliable results in the DMS, but the effects of growth and orthopedic treatments on the palatal surface should be investigated. Abdi et al.[28] also suggested that rugae points are clinically reliable for superimposition. Our RC measurement results were consistent with the findings of previous studies.

In our study, displacement of the teeth was performed using VS technology. The reality was imitated by a virtual approach. This could be considered as a limitation of the research. In real life, the height and width of the palatal alveolar process increases with the effect of craniofacial growth that continues during orthodontic treatment in some patients.[34] Therefore the pattern and location of rugae can possibly change.[35] In addition, when we achieve transverse tooth movement with maxillary expansion, the palatal vault expands and the rugae also undergo dimensional and positional changes.[32] All of these changes in the stability of the rugae may negatively affect the performance of the LB algorithm. However, with the method followed in our study, these factors that could have affected the results were eliminated, because no changes were observed in the rugae during the VS.

CONCLUSION

- It was not the type of tooth movement, but its degree that negatively affected LB superimposition performance. This was however too small (at micron level) to affect the measurements that evaluate the quantum of tooth displacement.
- The LBF method provided faster, easier, and more efficient overlaps. The performance of the LB algorithm was acceptable, but it required the operator to be very careful and precise with marking.
- The displacement of the RC measured after the LB method was not significantly different from the LBF method, which indicated that the 2 methods could be used reliably to evaluate the degree of teeth displacement.

Ethics Committee Approval: This study was approved by Afyonkarahisar Health Science University Clinical Research Ethics Committee.

Informed Consent: Written consent for publication was obtained from all the patients included in the study.

Peer Review: Externally peer-reviewed.

Author Contributions: Concept - H.C.; Design - H.C.; Data Collection and/or Processing - H.C., F.S.; Analysis and/or Interpretation - H.C., F.S.; Writing - H.C.; Critical Review - H.C.

Conflict of Interest: The authors have no conflicts of interest to declare.

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Original Article

An Updated Comparison of Current Impression Techniques Regarding Time, Comfort, Anxiety, and Preference: A Randomized Crossover Trial

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Main points:

- The time taken to obtain an impression in both techniques are similar.
- The digital scanning technique is more comfortable than a conventional impression technique.
- Patients prefer the digital technique compared to the conventional technique.

ABSTRACT

Objective: To compare digital and conventional impressions in terms of impression time, and comfort, anxiety, and preference of the patients.

Methods: Digital scans (Trios 3 Cart) and conventional impressions (irreversible hydrocolloid material, hand-mixed) were randomly performed on 39 patients by a single experienced operator at 14-21-day intervals (crossover design). The impression time, comfort score with the visual analog scale, anxiety level with the State-Trait Anxiety Inventory, and preference with a questionnaire, were recorded. The 2 techniques were compared with the independent *t*-test in terms of time, comfort, and anxiety. Patient–operator assessment and time–comfort relationship were analyzed using Pearson's correlation test.

Results: No statistical difference was found between the 2 impression techniques in terms of time ($P = .231$). Both the operators' and patients' comfort scores showed that the digital technique was found to be more comfortable ($P < .001$). There was no statistical difference between the 2 techniques with regard to anxiety ($P = .668$). The patients' and operators' comfort scores showed a strong correlation ($P < .001$), but no correlation was found between comfort and time ($P > .05$).

Conclusion: Digital scanning and conventional dental impression were similar in terms of impression time and anxiety of patients. However, patients were more satisfied with the digital technique, and preferred it.

Keywords: Intraoral scanner, dental impression, patient comfort, dental anxiety, clinical efficiency

INTRODUCTION

Dental models are indispensable instruments in diagnosis and in treatment planning, and plaster models obtained by conventional impressions are widely used in their fabrication.[1] Today, the high prevalence of conventional plaster models in clinical practice is due to the high cost of intraoral scanners (IOSs) and software programs.[2] However, digital scans stand out when compared to dental models, due to factors such as model fragility and the excessive space needed for the storage of plaster models.[3,4] Digital scans have many advantages, such as easy storage and back up,[5,6] as well as the effortless transfer of records between clinicians, dental laboratories, and patients.[7] Due to these advantages and the expectation that costs will fall in the future, digital scans are becoming an increasingly viable alternative or replacements for plaster models.[8,9]

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With the declining doubts about the accuracy of digital scans and the increase in their popularity, interest in patient-oriented issues (comfort, anxiety, and preference) that arise during the use of IOSs has also increased.[10] Specifically, the experience of using IOSs may be disturbing to some patients because of size of the scanner head[11] and the potential for uncomfortable heat.[12] However, the greatest advantage of digital techniques compared to conventional impression techniques in terms of comfort is the potential to prevent the gag reflex, allowing for work to be done away from the soft palate.[13,14] Studies have been conducted on this issue and many of them have investigated it with regard to patient comfort.[12,13,15-18] In addition, anxiety tests, which assess comfort indirectly, are an important parameter in measuring patient comfort. They are performed immediately after the impression has been used in other procedures of dentistry[19] and in similar studies.[12,17]

Another factor that affects the comfort of the patient and the operator is the time required to obtain the impression. Grünheid et al.[20] stated that the reasons for preferring the conventional technique over the digital technique are related to its simple workflow and shorter impression time. This preference remains even when patients do not like the taste of conventional impressions. In addition to the study by Grünheid et al.,[20] other studies indicate that conventional impression techniques are more effective in terms of time.[2,17,21,22] In some studies, however, no difference was found between the impression times of the 2 techniques,[16] while in others, it was noted that the digital technique takes less time.[12,13,15] These contradictory results are not surprising because research has been conducted using different techniques, such as complete[12,15] or regional[13] intraoral scans, scanners with different software and hardware features (scanner head size, heating, workflow, etc.),[11,18] and operators with different levels of experience.[2,21] This shows that existing studies comparing the impression techniques with regard to time, comfort, and anxiety are inadequate, and demonstrates the need for more study.

The aim of this study was to compare the digital and conventional impression techniques with a standardized procedure (single operator, same patient, same procedure, and randomization) in terms of impression time, and comfort, anxiety, and preference of the patient.

METHODS

This study was conducted on 39 patients (27 females and 12 males; mean age: 21.73 $\pm$ 7.86) who were recruited through the İstanbul Okan University Faculty of Dentistry. The number of 39 individuals was determined by a power analysis using the PiFace 1.72 program. As the basis for this analysis, we used values obtained by previous similar studies[12] in which the visual analog scale's (VAS) variability (SD) was 18.37. The mean difference was estimated to be 11, according to the same study, and type I error (α) was set at .05, as is standard. In this way, 92.3% power was obtained for the 2 groups.

When including individuals in the study, patients who needed conventional impressions as part of their treatment (for orthodontic appliances, prosthetics rehabilitation, guides for implant surgery, etc.) were selected, and digital scans were taken as a routine diagnostic record. This was considered a prerequisite for the study.

Additionally, individuals were also chosen based on the following criteria:

- No previous history of digital scan or conventional impression,
- No more than 6 teeth missing in either the maxillary or mandibular arch,
- Periodontally healthy; no gingival bleeding or related pain,
- No restriction of mouth opening or TMJ disorder that may cause pain, and
- Not using neuropathic or psychosomatic drugs.
- Prior to the study, the patients or their legal representatives signed an informed consent form, and approval for the study was obtained from the Ethics Committee of the Faculty of Dentistry of Marmara University (Protocol no. 224/2018).

Since this clinical study had a crossover design similar to those of previous studies,[12,13,22] digital scans and conventional impressions were obtained randomly from the same patients at an interval of 14-21 days. Randomization was generated with the Excel program (Microsoft, Redmond, WA, USA) and allocation was hidden in consecutively numbered, closed envelopes. According to this, half of the patients first had conventional impressions and the other half had digital scans. These impressions were made by a single operator (HY) who was experienced in both techniques.

Digital scans were obtained from patients with a current IOS (Trios 3 Cart, Color-2017, 3shape, Denmark) as a routine diagnostic record. In the digital scan procedure, 4 steps of the IOS interface were followed sequentially: patient registration, mandibular scan, maxillary scan, and bite scan. The scans were done between the second molars in the maxillary and mandibular arches. Care was taken not to leave any missing areas; if missing areas remained, only that area was scanned, without the impression being repeated. Specifically, the scans were done based on the patterns suggested by the IOS company. Each of these 4 steps, was timed by the observer (FAK), a dentist, who recorded separately on the follow-up form. The same observer also recorded the patient's behaviors based on the presence or absence of the following 7 criteria: eye squeezing, hand-foot movement, difficulty in breathing, queasiness, gag reflex, vomiting, and crying. Immediately after the completion of the digital scanning, the patient completed a VAS index for 7 criteria including: general feeling, difficulty in breathing, heat–cold discomfort, smell-taste discomfort, queasiness, gag reflex, and pain. In addition to this, patients also completed the Spielberg State-Trait Anxiety Inventory TX 1 (STAI-TX 1) form, which is one of the tests used in similar studies to determine anxiety after a digital scan.[12,17] The STAI is a commonly used measure of trait and state anxiety. It can be used in clinical settings to diagnose anxiety and to distinguish it from depressive syndromes.[23]

The patients were brought back after 14-21 days and conventional impressions were obtained using an irreversible hydrocolloid impression material (Hydrogum 5, Zhermack, Badia Polesine, Rovigo, Italy), according to recommended water/powder ratio by the manufacturer (mixed manually by the same operator). In order to ensure accurate comparison to the digital technique, the same sequence of steps was recorded separately for the conventional impressions: tray selection, impression of the mandibular arch, impression of the maxillary arch, and bite registration with dental wax in 1 piece. The impressions of the maxillary and mandibular arches were obtained to include the region between the second molars. If the observer detected a missing or faulty area in the maxillary or mandibular arch or in the bite, that step was repeated without being timed. Procedure times were recorded separately in each of the 4 steps and the presence or absence of the same 7 comfort criteria was recorded. Immediately after the conventional impression procedure, patients completed the comfort form, which was prepared with the VAS index and included the same comfort criteria as those in the digital technique, and the STAI-TX 1 test. Lastly, the patients completed a questionnaire comparing the digital and conventional techniques.

The obtained data were analyzed with the SPSS program (Version 25.0; IBM Corp., Armonk, NY, USA). The Shapiro–Wilk test was used to check whether the variables in the digital and conventional groups were normally distributed. The independent *t*-test with a 95% confidence interval was used to compare numerical variables that were normally distributed. Variables without normal distributions were compared using the Mann–Whitney *U*-test. In addition, Pearson's coefficient correlation test was used to test the time–comfort relationship and the correlation between patient and operator comfort assessments. $P < .05$ was considered a significant difference in all statistical tests.

RESULTS

The impression times of the digital and conventional techniques obtained from these individuals at each stage were compared separately in Table 1. Although the digital scan took less time than the conventional impression in tray selection, scanning of the maxillary arch, scanning of the mandibular arch, and total time, showed no statistically significant difference ($P > .05$). However, the conventional technique took less time than the digital technique only in terms of bite scanning, but again, no statistical difference was found ($P > .05$).

The comparison of comfort and anxiety scores of patients for digital and conventional techniques are shown in Table 2. The digital technique was more comfortable in terms of eye squeezing, hand-foot movement, difficulty in breathing, and queasiness, in the operators' assessment ($P < .05$). The digital technique was superior to the conventional technique again in terms of gag reflex, vomiting, and crying, but no statistically significant difference was found ($P > .05$). According to the patients' assessment, the digital technique was more comfortable in terms of general feeling, difficulty in breathing, smell-taste discomfort, queasiness, and gag reflex ($P < .05$). In addition, although patients scored the conventional technique as being more comfortable in terms of heat–cold and the digital technique as being more comfortable in terms of pain, these differences were not statistically significant ($P > .05$). When both the total discomfort score recorded by the operator and the average score of the VAS completed by patient were examined, the digital scan was found to be more comfortable than the conventional impression ($P < .001$). For patients, who evaluated self-trait anxiety after the impressions, the digital technique was superior, with a slight difference. However, this difference was not statistically significant ($P = .668$).

Table 3 shows the results of correlation between patient comfort scores, operator comfort scores, and impression times. There was a strong correlation between patients' and operators' comfort assessments ($R = .64$), and this correlation was statistically significant ($P < .001$). However, increasing impression times in both digital ($R = -.008$) and conventional ($R = -.121$) techniques had no effect on the patients' comfort assessments ($P > .05$).

Figure 1 shows the patients' preferences with respect to the questionnaire that compared the digital and conventional techniques. In line with our results from the comfort assessments, 84.6% of patients said that the "digital technique was more comfortable." Although there was no statistical difference in impression time or anxiety score, interestingly, patients stated that the conventional technique took more time (48.7%) and caused more stress (71.8%).

DISCUSSION

Now that IOSs are no longer considered to be experimental and are being used in clinics and laboratories, one of the most researched issues in IOSs is—as is the case for many new

Table 1. Impression time(s) results for the 2 techniques

	Digital ($N = 39$)			Conventional ($N = 39$)					
Variables	Mean	SD	SE	Mean	SD	SE	*df*	*F*	*P*
Patient Registration and Tray Selection (s)	51.74	12.91	2.07	60.13	23.80	3.81	76.00	.75	.057†
Maxillary Arch (s)	176.85	45.47	7.28	182.77	90.25	14.45	76.00	2.86	.715†
Mandibular Arch (s)	174.62	54.32	8.70	197.82	106.17	17.00	56.62	8.54	.229†
Bite Registration (s)	69.64	31.54	5.05	65.051	13.62	2.18	51.70	28.66	.408†
Total (s)	472.85	105.36	16.87	505.77	133.58	21.39	76.00	2.21	.231†

†Student's *t*-test. $P < .05$ Statistical significance from other groups.
S, second; SD, standard deviation; SE, standard error.

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Table 2. Comparison of clinician observation, VAS, and anxiety scores between the 2 techniques

Variables	Digital (N = 39)			Conventional (N = 39)			
Observation by Clinician	**Mean**	**SD**	**SE**	**Mean**	**SD**	**SE**	***P***
Eye Squeezing	6.23	7.18	1.15	11.72	5.55	.89	<.001††
Hand-Foot Movement	1.47	4.39	.7	6.59	7.21	1.16	<.001††
Difficulty in Breathing	0	0	0	2.93	5.84	.94	.003††
Queasiness	1.47	4.39	.7	8.06	7.18	1.15	<.001††
Gag Reflex	1.47	4.39	.7	3.66	6.32	1.01	.079††
Vomiting	0	0	0	.37	2.29	.37	.317††
Crying	0	0	0	.37	2.29	.37	.317††
Overall Discomfort Score	10.62	17.25	2.76	33.70	25.49	4.08	<.001†
VAS Scores by Patient							
General Feeling	6.03	14.76	2.36	20.28	28.55	4.57	.008†
Difficulty in Breathing	3.97	12.14	1.94	12.9	24.60	3.94	.045††
Smell-Taste Discomfort	1.7	5.58	.89	12.18	20.16	3.23	.002††
Heat–Cold Discomfort	2.18	3.58	.57	1.56	3.80	.61	.311††
Queasiness	6.64	14.43	2.31	24.23	32.11	5.14	.001††
Gag Reflex	4.95	10.59	1.7	18.23	30.45	4.88	.019††
Pain	3.46	9.54	1.53	2.92	5.46	.87	.436††
Average VAS Score	4.14	7.75	1.24	13.19	16.45	2.63	<.001††
Stress Scores by Patient							
STAI-TX 1	25.61	8.14	25.62	26.38	7.63	1.22	.668†

†Student's *t*-test. ††Mann–Whitney *U*-Test. $P < .05$ Statistical significance from other group.
SD, standard deviation; SE, standard error; df, numerator degrees of freedom.

technological devices—the working speed. Many studies have been conducted on this topic.[12,15-18,20,22] However, there is still no clear consensus on the chairside time of different impression techniques in the literature due to bias and differences in techniques.[24] In addition, this may be related to the fact that the software and hardware of IOSs are continuously being improved. Therefore, comparisons of digital scans with conventional impressions, whose technology is generally unchanged, may differ depending on when the study was done. In this study, the chairside times between the 2 techniques were compared at each step (patient registration/tray selection, maxillary arch, mandibular arch, and bite scan/registration) and although no statistically significant difference was found ($P > .05$), the digital technique took less time for patient registration, and in obtaining maxillary arch and mandibular arch impressions. Conversely, the conventional technique only took less time in terms of bite registration, although the difference was not statistically significant. In our experience, while the digital technique does not involve time-consuming procedures such as wax heating, the reason that bite scanning more took time in the digital technique may be related to software problems during scanning or the inability to scan the posterior region, which is becoming increasingly narrow due to the changing size of the scanner head.[11] Furthermore, the comparison of chairside time of the 2 techniques in other studies was similar to the findings in this study.[1,10]

Table 3. Coefficients of correlation between patients' assessment and operators' assessment and the total impression time

Variables	*R*	R^2	Correlation†††	*P*
Discomfort score by clinician	.64	.41	Strong positive	<.001†††
Impression time				
Digital	−.008	−.000	Weak positive	.962†††
Conventional	−.121	−.014	Weak positive	.462†††

†††Pearson's correlation coefficient test. $P < .05$ Statistical significance from other group. *R*, definition of coefficient of correlation.
SD, standard deviation; SE, standard error.

Patient comfort is significantly reduced due to the stimulation of the gag reflex during the conventional impression-taking process, especially in patients with sensitive gag reflexes.[15] Some patients even say that the worst experience in dentistry is the triggering of the gag reflex during the impression procedure.[22] In addition, the smell and taste of conventional impression materials can contribute to discomfort.[25] Digital scans obtained with IOS have great potential to eliminate the negative effects of conventional impression materials.[13,14] When total comfort scores in both patients' and operators' assessments were taken into consideration, the digital technique was reported as more comfortable than the conventional technique. These results are supported by many current studies.[12,13,15-18] As comfort scoring in patients' VAS showed, the digital technique was more comfortable in terms of general feeling, difficulty in breathing, smell-taste

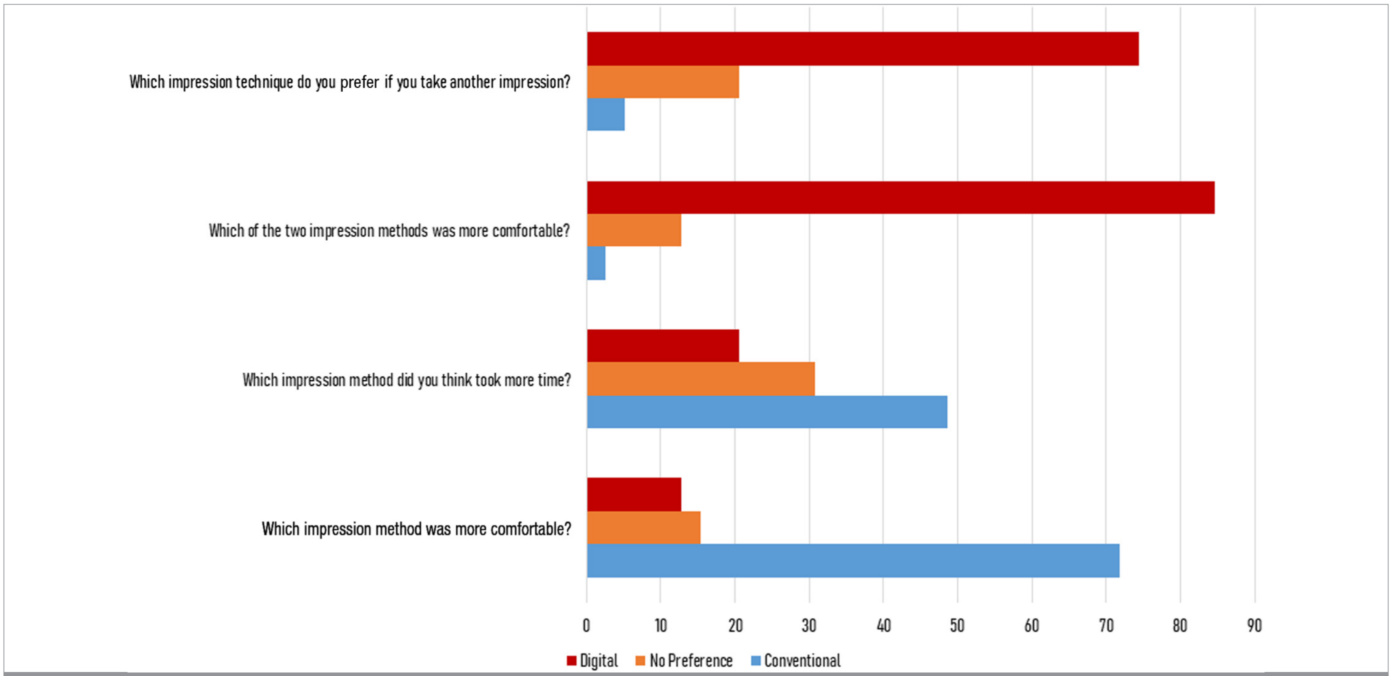

Figure 1. The results of the questionnaire filled by the patients, comparing the 2 techniques.

discomfort, queasiness, and gag reflex ($P < .05$). On the other hand, the patients' VAS scores showed that the conventional technique was more comfortable in terms of heat–cold discomfort, although the difference was not statistically significant. This may be related to the heating of the scanner head during digital scan. In addition, when patients were asked in the questionnaire, "Which technique was more comfortable?" 84.6% of the patients answered that the digital technique was more comfortable, while only 2.6% preferred the conventional technique. The questionnaire responses, which consisted of patients' self-perceptions, and the VAS results were consistent. This can be interpreted as taking into consideration the correct criteria for comfort.

Grünheid et al.[20] compared the comfort, preference, and time of digital and conventional impression techniques, and stated that patients rated the conventional technique as more comfortable because it took less time. Although they claimed that chairside time can affect comfort, this was not tested in their studies. It was tested in this study and revealed no correlation in impression time and comfort scores in either the digital or the conventional technique. Although there was no statistical difference in terms of time between the 2 techniques, when patients were asked, "Which impression technique took more time?", 48.2% of the patients stated that the conventional technique took more time, and only 20.8% said that the digital technique took longer. This surprising situation can be interpreted as a positive change in patients' perception of time, according to which the impression technique was more comfortable—the less comfortable technique seemed to take more time. The inconsistency of the numerical data and the answers to the subjective questionnaire on time–comfort correlation raises doubts about which is correct and reveals the need for further study. We aimed to increase the reliability of the comfort assessment results by using the same criteria for both patients and operators, and we found a strong correlation between patients' and operators' comfort assessments ($R = .64$, $P < .001$). Grejvold et al.[15] examined impression comfort assessments done by patients and operators, and also reported a strong correlation between the 2 assessments.

Patient anxiety, stress, and fear are important issues in dentistry, and the effects that different dental procedures have on patients have been studied.[19,26] Because a number of patients experience anxiety during impression procedures, several studies have evaluated this using anxiety tests.[12,17] It is natural to think that the potential of digital techniques to improve comfort will also be effective in reducing patient anxiety. However, no statistical difference was found between the 2 techniques in previous studies that examined trait anxiety of patients after digital and conventional techniques.[12,17] The results of this study support these studies; we found no statistically significant difference between the anxiety scores of the 2 impression techniques. Interestingly, in the questionnaire comparing the impression techniques, 71.8% of the patients stated that they felt more stress in the conventional impression technique. This may be explained by the inadequacy of the anxiety scale used to evaluate dental procedures or by the fact that although impression techniques affect comfort, their psychosocial effects are limited. Also, when asked, "Which impression technique would you prefer if you take another impression?", 74.4% of the patients preferred the digital technique and 5.1% preferred the conventional. Other studies investigating patient preference have also found similar results.[2,12,13,16-18,20,22]

Previous studies have compared digital and conventional impressions either by obtaining them from different patients or from the same patient.[12,14,20] In cases where the same patient compared the 2 impression techniques, more reliable results were obtained. However, when different impressions were obtained from the same patient, this caused a carryover effect that confused patients and affected which impression technique they preferred.[14,22] For this reason, some studies that took both impressions from the same patient used a crossover design to take this factor into consideration,[12-14,22] whereas other studies ignored this and took 2 impressions consecutively.[20,21] In order to avoid these effects and to increase the reliability of this study, we took 2 different impressions from the same patient with a crossover design at intervals of 14-21 days. Having impressions obtained from the same patients by the same operator is also an important issue because each operator's level of theoretical knowledge, practical experience, and ability in both impression techniques may differ. For example, the time required to perform acceptable intraoral scans decreases with increasing experience,[27,28] and this can affect the comfort scores and time.[13,14,22] Therefore, this study was conducted with a single operator who had taken at least 100 impressions using both impression techniques. It can be said that the findings of this study are more reliable than other studies due to the clinical perspective and detailed operator selection.

Studies that examined precision and accuracy of IOSs have reported that different scanning patterns in the digital scan procedure affect impression time and accuracy.[20,29,30] Thus, the single scanning pattern described in the IOS company user guide was used for all digital scans. The VAS index, which is a reliable technique that includes different criteria that increase the scope, was used in this study, even though other studies that examined impression comfort have similar criteria.[12,16,17] In addition to the criteria from similar studies, we also included criteria that the operator can assess based on the patient's movements (eye squeezing, hand-foot movement, etc.) as well as the VAS index that is scored by patients. Operators' assessment criteria may have prevented the patient from giving incorrect information with the VAS and may have provided more objective results. In addition, we used the STAI-TX 1 scale for anxiety assessment because it is widely accepted in psychological tests and is preferred in dental anxiety studies.[12,17]

This study had some limitations, the first of which was the use of only one type of conventional impression material (alginate impression material from a single company) and technique (hand-mixing), and comparison with a single brand of IOS. Digital scans can be obtained with other IOSs with different hardware (scanner head size, camera quality, etc.) and software features. In addition, different comparisons could be conducted by changing type, brand, and mixing (i.e., with a machine) of the conventional impression. However, although it limited this study, we thought that it would be unethical to use such a variety of different inputs on the same patient. The second limitation was that only one operator who was experienced in both impression techniques was used. The studies have compared dentistry students[31] inexperienced in both impression techniques, and prosthetic residents[28] experienced only in the conventional technique in terms of impression technique preference. Considering that patient comfort could be affected by the experience of operators, the scope of this study could be increased by including operators with different levels of experience.

CONCLUSION

Within the limitations of this study:

- The time efficiency of digital and conventional techniques was similar, both in total impression time and in each step.
- Patients were more comfortable with the digital technique according to both the patients' and operators' assessments.
- Patients' anxiety was not affected by the impression techniques.
- The patients' preference was for the digital technique.

Ethics Committee Approval: Ethics committee approval was received for this study from the Ethics Committee of the of Marmara University Faculty of Dentistry (Protocol no. 224/2018).

Informed Consent: Written informed consent was obtained from the patients or their legal representatives.

Peer-review: Externally peer-reviewed.

Author Contributions: Design - H.Y.; Data Collection and/or Processing - H.Y., F.A.K., M.N.A.; Analysis and/or Interpretation - H.Y.; Writing - H.Y., F.A.K., M.N.A.

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Original Article

Dental Anxiety and Fear Levels, Patient Satisfaction, and Quality of Life in Patients Undergoing Orthodontic Treatment: Is There a Relationship?

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Main Points

- Fear, anxiety, and quality of life are all topics that have been discussed extensively in the literature.
- A positive relationship between the doctor and the patient has a positive impact on both dental anxiety and the OHRQoL.
- There exists a significant relationship between dental anxiety levels and OHRQoL.

ABSTRACT

Objective: This study aimed to evaluate the relationship between dental anxiety and fear levels, patient satisfaction, and oral health-related quality of life (OHRQoL) in patients undergoing orthodontic treatment.

Methods: The study was conducted in the Department of Orthodontics, Sivas Cumhuriyet University Faculty of Dentistry. This cross-sectional study included 252 patients, aged 11-14 years undergoing orthodontic treatment. The data collection tools were the Index of Dental Anxiety and Fear (IDAF-4C$^+$), the Child Perceptions Questionnaire (CPQ 11-14), the Patient Satisfaction Questionnaire, and the Clinical Examination Data Form. The CPQ 11-14 was used to measure OHRQoL. Descriptive statistics, the independent samples *t*-test, analysis of variance (ANOVA), Cronbach's alpha, and Pearson coefficient were used for statistical analysis at a significance level of 0.05.

Results: The CPQ 11-14 parameters were sufficiently reliable, and the patients mostly had problems with oral symptoms. A significant difference was observed between the type of treatment, the initiation of treatment, emotional well-being, and social well-being ($P < .05$). The relationship between treatment satisfaction and all parameters was significant ($P < .05$). There was a significant relationship between IDAF-4C$^+$ and CPQ 11-14, while a moderate correlation was found between dental anxiety and emotional well-being.

Conclusion: According to the results of this study, the type of treatment, the initiation of treatment, and dental anxiety impact the quality of life. It was found that treatment satisfaction and a positive patient–dentist relationship positively affect the quality of life and dental anxiety.

Keywords: Personal satisfaction, dental anxiety, oral health

INTRODUCTION

Dental fear is a normal emotional response to threatening stimuli in dental treatments. Dental anxiety is defined as the response to a specific stressful stimulus. Dental anxiety is considered to be a condition.[1] Patient anxiety is a frequently encountered problem in most areas as the emotional expression of a normal state of anxiety or a pure and specific psychological fear of dentistry and medicine.[2] Mild fear and anxiety are compatible with normal development and expected experiences, but when fear and anxiety increase disproportionately, they disrupt daily functionality and need treatment.[3] In a study conducted among 200 patients undergoing orthodontic treatment, high degrees of dental fear were identified in young adults, and the most feared dental procedure was extraction.[4] In another study in which 675 patients were evaluated, it was reported that dental

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anxiety was affected by the relationship with the orthodontist, orthodontic treatment perspective, and treatment factors.[5] The oral health status of anxious individuals is generally poor, and treatment is complicated, with longer sessions.[6] Moreover, these patients are usually dissatisfied with the treatment experience.[7] Anxiety appears as an important issue in orthodontics patients and is likely to affect the process of treatment.

Different methods have been developed to measure dental anxiety and fear. There is considerable literature examining the cognitive aspects of dental fear. For example, the Dental Belief Scale measures the subjective perception of dentist behavior, and the lack of power, control, and trust, and has been associated with dental fear.[8] There are many theoretical and practical limitations in measuring dental anxiety and fear. The Index of Dental Anxiety and Fear (IDAF-4C$^+$) is a self-reported measurement tool and examines dental anxiety and fear related to 4 components: cognitive, behavioral, emotional, and physiological. This measurement tool addresses dental anxiety and fear theoretically and psychologically.[9]

Patient satisfaction has become an important area of interest in the healthcare sector. Age, gender, motivation, anxiety, and discomfort affect the satisfaction level. Conditions such as discomfort from orthodontic appliances and the patient's anxiety cause dissatisfaction.[10] The quality of the service provided and the patient's expectations may affect patient satisfaction. A vast majority of individuals need orthodontic care.[11] It is essential to identify the percentage of patients who have received orthodontic therapy and are satisfied with the treatment outcomes. A study showed that 34% of patients were completely satisfied, 62% of patients were moderately satisfied, and 4% were dissatisfied with the orthodontic treatment rendered.[12] It is important for orthodontists to know the factors that will affect adolescent patients' satisfaction with orthodontic treatment.[13] The level of motivation, expectation, and subjective satisfaction after orthodontic treatment could be considered as important parameters in measuring the overall results and importance of orthodontic treatment.[10] Various surveys have been developed to measure patient satisfaction, for example, The Patient Satisfaction Questionnaire. In this survey, doctor–patient relationship, situational aspects, psychosocial and dentofacial improvements, and dental function are evaluated.[14] It is seen that doctor–patient relationship has an important place in measuring satisfaction.

The assumption that the dentoalveolar status is one of the most important factors in smile esthetics, attractiveness, and happiness has led to an increase in the popularity of orthodontic treatment in children and adults, which is indicated by the concept of oral health-related quality of life (OHRQoL).[15] OHRQoL is defined as a positive sensation that leads to the development of dentofacial self-confidence and an absence of the adverse effects of poor oral conditions on social life. Oral health has a significant impact on the physiological, social, and psychological health of a person.[16] The Child Perceptions Questionnaire (CPQ)-11-14 takes a broad look at oral, dental, and orofacial disorders.[17] During orthodontic treatment, the patient may encounter difficulties while eating, drinking, speaking, and in maintaining oral hygiene, depending on the type of treatment.[18] These challenges may also affect patient satisfaction.

As a result of the literature review, it is thought that there may be a relationship between dental anxiety and fear and quality of life.[19] The relationship of these factors with patient satisfaction is uncertain. This study aimed to evaluate the dental anxiety and fear levels, satisfaction status, and OHRQoL of patients undergoing orthodontic treatment, and to investigate the relationship between these factors. The null hypothesis of this study was that there was no relationship between patient satisfaction, quality of life, and dental anxiety and fear.

METHODS

Ethical Approval

Approval was obtained from Sivas Cumhuriyet University Clinical Research Ethics Committee for the study with the written and oral consent of the patients and their parents. (Ethics Committee decision no: 2018-12/15)

Study Group

The study was conducted in the Department of Orthodontics, Sivas Cumhuriyet University Faculty of Dentistry. The sample was selected using the convenience sampling method. This cross-sectional study included 252 patients who were 11-14 years of age, undergoing orthodontic treatment at the orthodontic clinic of the faculty of dentistry. The patients included in the study were treated by orthodontists (G.E and Z.Ç.B) who were educated at the same university clinic, had the same experience, and were found to have a good relationship with the patients. The orthodontists participating in the study were calibrated before the study. At the beginning of treatment, patients were given the same directives and directions by the orthodontists. We collected data from January 2019 to October 2019. In this study, the minimum sample size calculated was 252 persons, considering a level of significance of 5%, test power of 90%, and minimum detectable odds ratio of 1 : 5.[20] The average quality of life scores in the sample article were used to calculate the effect size.

Individuals without any mental disorders were included in the study. The presence or absence of a mental disorder was determined by expert consultation. Patients with any syndrome were excluded from the study. Patients who received extracted, non-extracted or removable-fixed treatment type were included. Single-arch (Tanzo Cu-Niti, American Orthodontics, USA), MBT .022" bracket system (Mini Master American Orthodontics, USA), and MBT system space-closing technique (extracted cases) were used in all patients receiving fixed orthodontic treatment.[21] Clark's[22] modified twin-block appliance was used as a functional appliance in all patients receiving the STROBE checklist.

Data Collection

All measurements were made during the treatment just before the control session, in a private room, and by the patient herself/himself. Parents were instructed to wait outside while only patients were taken into the private room.

Index of Dental Anxiety and Fear-4C$^+$

This index was developed in 2010 to measure dental anxiety and fear in patients. The IDAF-4C$^+$ has strong theoretical bases but is also practical enough for application in a variety of potential uses.[23] It consists of 4 components: cognitive, behavioral, emotional, and physiological. It contains 8 questions that can be answered through a 5-point Likert-type scale, ranging from strongly disagree (1 point) to strongly agree (5 points). The scores are collected and averaged, and if the average score is <1.5 no anxiety is indicated, average score of 1.5-2.5 indicates low anxiety, 2.5-3.5 indicates medium anxiety, and average score> 3.5 indicates high anxiety. The Turkish version of the index was developed in 2017, and its validity and reliability have been tested.[9] This index is appropriate for children aged 12 to 14.[9] It was determined before the start of the study that it could be applied to children 11-14 years of age, with a pilot study.

Clinical Examination Data Form

This form was used by the researcher to record sociodemographic data such as age, gender, the duration of treatment, and the type of treatment.

Patient Satisfaction Data Form

The patients were asked the following questions to assess satisfaction status (4-point scale): Are you satisfied with the service provided at the university? Are you satisfied with your dentist? Considering everything, how satisfied are you with the orthodontic treatment?

LITERATURE REVIEW

With the keyword "patient satisfaction," an 8-item question pool was created with general questions by examining various articles written in the field, from Google Scholar, PubMed databases and clinical experiences. Of the questions prepared for the content of the study, 3 were found suitable, based on the expert opinions of orthodontists. Concurrently, the focus group interview was conducted with 5 patients, and the comprehensibility of the questions in the questionnaire was evaluated. The final version of the questionnaire was applied to 20 patients who were not included in the study, at 2-week intervals. Cronbach's alpha, for the internal consistency of the patient data form, was found to be 0.744. Factor analysis was performed to measure the validity of the patient data form, and KMO was calculated to be 0.735 as a result of the test. One factor was determined as a result of the factor analysis and this factor was collected in 60.032 of the variance. The factor loading range of the items fulfilled the requirement to be greater than 0.30. These values have shown that the patient data form is valid and reliable.

Child Perceptions Questionnaire 11-14

The CPQ 11-14 was developed for children aged 11-14 years with dental, oral, and orofacial problems. The CPQ 11-14 was used for the assessment of OHRQoL. The scale consists of 39 questions, including 2 general questions on oral health and its impact on life, and 37 questions on 4 subjects. The first 2 general questions assess the child's perception of his/her oral health and its impact on his/her life. Thirty-seven questions in the scale are about the frequency of events and emotions experienced by the child in the previous 3 months due to conditions associated with the teeth, lips, and jaws. These questions include oral symptoms (6 questions), functional limitations (9 questions), emotional well-being (9 questions), and social well-being (13 questions), respectively. The scale has a Likert-type structure, and the response options are as follows: 0 = never, 1 = once or twice, 2 = sometimes, 3 = often, and 4 = every day or almost every day. The total score obtained from the scale is calculated by adding all the points across the 37 questions. The higher the score, the worse the quality of life due to oral health.[17] The validity and reliability of the scale were published in 2002 by Jokovic et al.[17] The Turkish version of the CPQ 11-14 scale was prepared by Aydoğan within the scope of the thesis study, and showed sufficient evidence for validity and reliability.[24]

Statistical Analysis

The data collected from our study were analyzed using the SPSS program (Version 15.0, IBM Corp. New York, USA). The compatibility of the numerical data with the normal distribution was evaluated by the analysis of the skewness and kurtosis coefficients. Huck[25] states that the skewness and kurtosis values should vary between −1 and +1 in order to show the normal distribution of the data. Mean, standard deviation, and frequency distributions were studied in the data evaluation. Cronbach's alpha internal consistency coefficients of the CPQ subscales were calculated. The repeated-measures analysis of variance (ANOVA) test was used to determine whether there were significant differences between these 4 scores. The relationship between gender and IDAF and OHRQoL was evaluated by the independent samples *t*-test, and the relationship of IDAF and OHRQoL to the duration of treatment, the type of treatment, and the satisfaction status was evaluated by the ANOVA test. The correlation between the IDAF and OHRQoL scores was calculated using the Pearson correlation coefficient. Inter operator comparisons were made using independent samples *t*-test.

RESULTS

The questionnaires were applied to a total of 270 individuals, out of whom 18 were excluded because their answers were incomplete. Female participants comprised 62.3% (157), while 37.7% (95) were male. The mean age was found to be 13.18 years.

The results of the reliability analysis of the CPQ 11-14 scale used in our study were calculated for oral symptoms, functional limitations, emotional well-being, and social well-being, respectively. Cronbach's alpha coefficients for internal consistency of these parameters were 0.621, 0.769, 0.892, and 0.805, respectively. These data show that the parameter values have sufficient reliability. Reliability analysis of the CPQ 11-14 was undertaken for all participants.

The relationship and difference between IDAF and OHRQoL and gender, the duration of treatment, the type of treatment, and satisfaction status are given in Table 1. Female patients had higher OHRQoL scores than male patients ($P = .495$, $P > .05$). These results showed that males' quality of life was better than

Table 1. Assessment of the relationship between variables and dental anxiety and fear levels, and oral health-related quality of life

			CPQ 11-14			
Variables	*N*	**IDAF 4C+ (Mean ± SD)**	**Oral symptom (Mean ± SD)**	**Functional limitations (Mean ± SD)**	**Emotional well-being (Mean ± SD)**	**Social well-being (Mean ± SD)**
Gender						
Female	157	1.41 ± 0.56	1.50 ± 0.71	1.30 ± 0.70	0.90 ± 0.82	1.06 ± 0.82
Male	95	1.42 ± 0.60	1.42 ± 0.62	1.23 ± 0.66	0.79 ± 0.72	1.01 ± 0.70
P		0.802[a]	0.342[a]	0.429[a]	0.265[a]	0.643[a]
Duration of treatment						
1-6 months	110	1.43 ± 0.60	1.42 ± 0.70	1.31 ± 0.74	0.90 ± 0.87	1.08 ± 0.90
6-12 months	33	1.38 ± 0.49	1.33 ± 0.84	1.12 ± 0.67	0.66 ± 0.50	0.91 ± 0.67
12-24 months	40	1.38 ± 0.45	1.53 ± 0.59	1.28 ± 0.69	0.93 ± 0.76	1.11 ± 0.72
24 months and more	69	1.42 ± 0.63	1.57 ± 0.58	1.30 ± 0.60	0.85 ± 0.77	0.99 ± 0.63
P		0.961[b]	0.274[b]	0.586[b]	0.460[b]	0.585[b]
Type of treatment						
Extracted fixed	76	1.36 ± 0.44	1.51 ± 0.61	1.30 ± 0.70	0.75 ± 0.74	1.00 ± 0.73
Non-extracted fixed	80	1.41 ± 0.67	1.40 ± 0.57	1.22 ± 0.58	0.70 ± 0.71	0.90 ± 0.69
Removable/ fixed	96	1.45 ± 0.57	1.50 ± 0.80	1.30 ± 0.76	1.07 ± 0.84	1.19 ± 0.85
P		0.557[b]	0.499[b]	0.703[b]	0.003*	0.047*
Initiation of treatment						
Voluntarily	235	1.40 ± 0.57	1.48 ± 0.68	1.27 ± 0.68	0.83 ± 0.77	1.00 ± 0.73
With advice	17	1.61 ± 0.52	1.38 ± 0.68	1.43 ± 0.82	1.30 ± 0.93	1.57 ± 1.09
P		0.139[a]	0.568[a]	0.361[a]	0.016[c]	0.003[c]
University satisfaction						
Not satisfied	3	1.91 ± 0.87	0.88 ± 0.67	1.25 ± 0.33	0.92 ± 0.84	0.77 ± 0.22
Slightly satisfied	10	1.85 ± 1.05	1.76 ± 0.73	1.57 ± 0.94	1.08 ± 1.10	1.25 ± 0.97
Moderately satisfied	72	1.45 ± 0.54	1.60 ± 0.51	1.40 ± 0.67	1.02 ± 0.81	1.14 ± 0.76
Very satisfied	167	1.36 ± 0.53	1.40 ± 0.72	1.21 ± 0.67	0.77 ± 0.75	0.99 ± 0.77
P		0.022*	0.039*	0.121[b]	0.112[b]	0.393[b]
Dentist satisfaction						
Not satisfied	1	2.75	0.5	0.88	1.66	1
Slightly satisfied	2	2.06 ± 0.97	1.33 ± 0.00	0.94 ± 0.78	0.94 ± 0.54	1.44 ± 1.09
Moderately satisfied	15	1.44 ± 0.48	1.85 ± 0.45	1.61 ± 0.59	1.35 ± 1.02	1.57 ± 0.73
Very satisfied	234	1.40 ± 0.57	1.45 ± 0.68	1.26 ± 0.69	0.82 ± 0.76	1.00 ± 0.77
P		0.046*	0.072[b]	0.223[b]	0.061[b]	0.047
Treatment satisfaction						
Not satisfied	1	3.87	3	3.55	3.22	2.66
Slightly satisfied	9	1.62 ± 0.66	1.20 ± 0.49	1.32 ± 0.40	1.37 ± 0.82	1.50 ± 1.04
Moderately satisfied	98	1.48 ± 0.50	1.61 ± 0.71	1.39 ± 0.71	1.09 ±0.86	1.23 ± 0.84
Very satisfied	144	1.33 ± 0.57	1.38 ± 0.64	1.18 ± 0.65	0.65 ± 0.64	0.87 ± 0.65
P		0.000*	0.004*	0.001*	0.000*	0.000*

[a]$P > .05$ independent samples *t*-test, [b]$P > .05$ one-way ANOVA, [c]$P < .05$ independent samples *t*-test.
*$P < .05$ one-way ANOVA.
IDAF 4C+, Index of Dental Anxiety and Fear.
CPQ 11-14, Child Perceptions Questionnaire.

that of females. When the duration of treatment was examined, different IDAF and OHRQoL scores were determined in patients in different treatment periods. Lower scores mean less dental anxiety and better quality of life. Significant differences were found between the type of treatment and the initiation of treatment, and emotional well-being and social well-being ($P < .05$). Significant differences were found between satisfaction with the service provided at the university and IDAF and oral symptoms

($P < .05$). A significant difference was observed between dentist satisfaction and IDAF and social well-being ($P < .05$). The relationship between treatment satisfaction and all parameters was also significant ($P < .05$).

When we examined the data on patient satisfaction, we observed that 66.3% of the patients were quite satisfied with the service provided at the university. The patients' rate of satisfaction with dentists was very high, at 92.9%. Satisfaction with orthodontic treatment was 57.1%.

The descriptive statistics from the CPQ 11-14 of the participants ($n = 252$) were 1.47 ± .68, 1.28 ± .69, 0.86 ± .79, and 1.04 ± .77 for oral symptoms, functional limitations, emotional well-being, and social well-being, respectively. The data suggested that the most frequently encountered problems were related to oral symptoms, functional limitations, social well-being, and emotional well-being. The repeated-measures ANOVA test was used to determine whether the differences between these 4 scores were significant. The analysis showed a significant difference between the groups ($P < .05$).

When we examined the correlation between dental anxiety and fear scores and the CPQ subscales, there was no significant relationship between IDAF and oral symptoms, as the significance value calculated for the Pearson correlation coefficient between IDAF and oral symptoms was $P > .05$. Pearson's correlation coefficient between the other parameters and IDAF scores was calculated as $P < .05$, suggesting a significant relationship between the other parameters and IDAF. Pearson's correlation coefficient and P values calculated for these parameters are given in Table 2.

The patients included in the study were treated by 2 different orthodontists. There was no significant difference between orthodontists in patient satisfaction, quality of life, and dental anxiety scores ($P > .05$).

DISCUSSION

In our study, the number of females (62.3%) was higher than the number of males, similar to earlier studies.[15,26] A possible explanation may be that girls attach more importance to their physical appearance than boys, and therefore, are more likely to seek orthodontic treatment. Moreover, female participants reported a higher impact on OHRQoL scores due to treatment than males. Thus, female patients complained about their facial appearance and also believed that the treatment received negatively impacted their lives.

IDAF was lower in females than in males, but this was not statistically significant ($P > .05$), a finding that does not corroborate with the results of previous studies.[27,28] Buldur et al.[9] showed that females had higher anxiety scores than males. Another study demonstrated that dental fear status was influenced by parental dental fear, regardless of age and gender.[29] The reason girls' anxiety levels were lower than boys in our study may be that girls pay more attention to their appearance. At the same time, these outcomes may have been affected by differences in the dental anxiety of parents and sociodemographic factors.

Anxiety can be influenced by a variety of factors. For example, Jamali et al.[30] found a relation between daily media consumption and anxiety. However, anxiety levels must be supervised over longer treatment times and with more complex treatments in order to better understand children's behavior.[30] Increases in treatment time have been related to worsening behavior and anxiety in pediatric patients, according to the literature.[31] Choi et al.[32] reported that the quality of life deteriorated with an increase in treatment time. In one study, lower fears were reported in patients whose treatment was continued compared to patients whose treatment had not yet been initiated.[5] This demonstrates that fear decreases as the treatment progresses. No significant relationship was found between the duration of treatment and IDAF and OHRQoL in our study, unlike these studies. The patient–dentist relationship, the patient's personality traits, or various socioeconomic factors can all be cited as reasons for this circumstance. Future research will be required to determine which factors are effective.

The dental fear levels in patients receiving invasive and orthodontic treatment are higher than in those receiving invasive therapy only and in those who have no experience of treatment.[33] We analyzed the relationship between the type of treatment and anxiety levels and OHRQoL in patients who received extraction-fixed, non-extraction-fixed, and removable-fixed treatment. We believed that the different experiences in all 3 groups would influence IDAF and OHRQoL. We found that the highest anxiety levels were associated with the removable-fixed treatment, while the anxiety levels were lower than expected

Table 2. Correlation between dental anxiety and fear scores and CPQ 11-14

Variables	Oral symptoms	Functional limitations	Emotional well-being	Social well-being	IDAF 4C+
Oral symptoms	-	.524*	.305*	.261*	.075
Functional limitations		-	.478*	454*	.222*
Emotional well-being			-	.642*	.370*
Social well-being				-	.275*
IDAF 4C+					-

*Pearson correlation ratio.
IDAF 4C+, Index of Dental Anxiety and Fear.
CPQ 11-14, Child Perceptions Questionnaire.

in patients who received the extraction-fixed treatment. A possible reason may be that the extraction was not performed by the orthodontist, as recommended in the literature.[33] Unlike our findings, Mustafa et al.[4] reported that extraction was the common cause of fear among patients. The highest anxiety levels observed in patients who received the removable-fixed treatment could be attributed to the patient–dentist relationship that plays a crucial role in this type of treatment. Data from the literature show that establishing a good patient–dentist relationship from the first visit positively affects patient compliance and cooperation.[34] The issue of cooperation in removable appliances has been the subject of various studies.[35,36] Parental attitudes and the doctor–patient relationship, according to Mirzakouchaki et al.,[37] have a significant impact on patient compliance. Patient compliance in treatment with removable appliances is beyond the control of the orthodontist.[37] We believe that the doctor–patient relationship may be negatively affected by the lack of cooperation, which may cause dental anxiety. In one research, patients with increased overjet had a poorer quality of life.[38] Orthodontic appliances, especially fixed ones, cause more difficulties while eating, according to Albaqami et al.[39] Eating difficulties were investigated in the study of Albaqami et al.,[39] and it was discovered that there were no difficulties because removable appliances can be removed while eating. Other conditions that may have an impact on daily life were also evaluated in our study. The use of removable orthodontic appliances was found to have a negative impact on the quality of life. The explanation for this situation was that the usage time of the removable appliances was long and the large volume covers the mouth.

Dental fear can be affected by the personality traits of the patient, which play an essential role in determining the level of social influences on behavior.[29] Psychological approaches are effective in increasing orthodontic treatment motivation, according to a study.[40] Patients wanted orthodontic treatment because it improved their self-esteem, according to another study.[41] Self-esteem has been reported to be effective against dental fear.[42] Banarjee et al.[43] reported that patient motivation improved the quality of life. In our study, we asked the patients if they had initiated the treatment voluntarily or because they were advised to. Higher IDAF and OHRQoL scores were observed in patients who sought treatment because they were advised to. These data show that patients who volunteered to receive treatment demonstrated better results in terms of dental anxiety and quality of life.

The process of patient management is as important as the outcome of treatment. Thus, it is essential to evaluate every stage of treatment from the patient's viewpoint and measure satisfaction to provide the best possible results.[44] Therefore, we assessed the level of satisfaction and found that the rate of dentist satisfaction strongly correlated with the dentist–patient relationship (92.9%). Our study showed higher IDAF scores in patients who were dissatisfied or less than satisfied with their dentist. Dental fear is known to affect patient cooperation and treatment success.[34] Successful orthodontic treatment is highly dependent on a positive patient–dentist relationship. Shahrani et al.[45] reported that 87.1% of patients were satisfied with orthodontic treatment, and the patient–dentist relationship was an important factor affecting satisfaction. A study by Aljughaiman et al.[26] revealed that the patient–dentist relationship received the highest satisfaction scores among participants in their study. Our results are in agreement with the findings of these studies, which have suggested that an association exists between the patient–dentist relationship, dental fear levels, and treatment success.

There is no doubt that there is a difference between the healthcare services provided in private or public institutions in terms of patient satisfaction. The quality of healthcare service affects patient satisfaction.[46] A study showed that patients were more likely to be satisfied with services received in public institutions.[26] Our study conducted showed a patient satisfaction level of 66.3%. A high level of IDAF was observed in patients who were not satisfied with the service received.

Patients who received orthognathic surgery were satisfied with the treatment and showed improved OHRQoL scores.[47] In patients treated with conventional brackets or the Invisalign system, post-treatment satisfaction and OHRQoL scores exhibited a positive change.[48,49] Studies show that patient satisfaction positively impacts the quality of life.[15,47,49] Our study suggested that the patients who were satisfied with the treatment experienced less anxiety and showed improved quality of life.

Dental anxiety negatively influenced oral health. High dental anxiety was associated with a low number of dental fillings and a high calculus index. A decline in oral health negatively impacts the quality of life.[50] Dental fear may decrease a child's OHRQoL scores, especially those for emotional and social well-being. Positive small treatment experiences may reduce this effect.[51] A significant relationship was found between OHRQoL and the socioeconomic status of the parent, dental anxiety, and oral health behaviors.[19] These data in the literature support our study, which showed a significant correlation between IDAF and OHRQoL scores, and a moderate correlation between IDAF and emotional well-being.

Our study was performed in a single clinic with a cross-sectional design. It would be more appropriate to conduct it in more than one clinic and with a prospective design. The strength of the study is the examination of the relationship of 3 different variables that are clinically important.

CONCLUSION

- Dental anxiety has an impact on the OHRQoL.
- Worse OHRQoL was observed in the removable-fixed treatment type. At the same time, higher dental anxiety was detected in this type of treatment. It may be beneficial for orthodontists to be more careful with this type of treatment.
- A positive patient–dentist relationship was characterized by low dental anxiety levels and better OHRQoL.

Ethics Committee Approval: Ethical committee approval was received from the Clinical Research Ethics Committee of Sivas Cumhuriyet University (decision no: 2018-12/15).

Informed Consent: Written and verbal consent was obtained from the patients and their parents.

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Original Article

The Assessment of Impact of the COVID-19 Pandemic on Patients Receiving Orthodontic Treatment

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Main Points

- Ortodontic treatments were significantly affected by the COVID-19 pandemic.
- Solving the problems faced by patients when they cannot visit their clinical check-ups reduces anxiety.
- Teleortodontics can also be an effective resource for reducing the number of visits to the clinics.

ABSTRACT

Objective: The aim of this study was to determine the difficulties experienced by patients receiving orthodontic treatment during the COVID-19 pandemic and to evaluate the problems experienced by orthodontic patients, along with their attitudes toward these problems.

Methods: A cross-sectional survey study including a total of 502 patients (291 female; 211 male) receiving orthodontic treatment at a public or private clinic was conducted via a web-based questionnaire.

Results: Of all participants, 70.1% (352) were between the ages of 12 and 18 and 77.1% (387) were treated in a public clinic. According to the results, 97.3% (372) of the patients in the public clinic and 71.1% (79) of the patients in the private clinics had not been able to continue their treatment for 2 months or longer. Most of the participants were concerned about extended treatment duration (349, 69.5%) during this period. While the most common problems in patients with fixed appliances were soft tissue irritation (230, 52.5%), bracket failure (142, 32.4%), gingival swelling (88, 20.1%), and pain (88, 20.1%); there were issues of new spaces between teeth (41, 64.1%), pain (37, 57.8%), and gingival swelling (29, 45.3%) among patients with removable appliances.

Conclusion: Most patient appointments were delayed during the COVID-19 pandemic. Patients experienced various problems with their treatment, and as a result, concerns about extended treatment duration increased. Therefore, orthodontists should pay more attention to teleorthodontics during the pandemic process.

Keywords: Anxiety, COVID-19, emergencies, orthodontic treatment, teleorthodontics

INTRODUCTION

Throughout history, pandemics have caused a high mortality rate and severe socio-economic crises in the affected countries. The outbreak of SARS-CoV-2, which started in China in December 2019, spread globally in a short time, and the disease was named COVID-19.[1] A global emergency was declared by the World Health Organization on January 30, 2020, and the outbreak was declared as a pandemic on March 11, 2020.[2] In order to prevent the spread of the pandemic, various measures have been implemented, such as regular maintenance of hand hygiene, use of face masks and social isolation. Most countries were placed under a total lockdown to prevent cross infection as the number of people infected increased.[3]

The average incubation period of COVID-19 is 5-6 days. The symptoms may appear within 2-14 days after contact, and contagiousness may begin within 1-2 days before the onset of symptoms.[4] The disease is mainly

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transmitted by droplets, and it is believed that droplets spread from the infected individual due to coughing, sneezing, and speaking, and are transmitted to sensitive individuals via contact/inhalation through the eyes, mouth, and nasal mucosa.[5] All age groups are susceptible to COVID-19. Various symptoms may be present at the onset of the disease; however, the predominant symptoms are fever and cough, while the gastrointestinal symptoms are less common. In addition to the predominant symptoms, patients may also experience headache, conjunctival hyperemia, nasal congestion, sore throat, increased secretion, sputum, weakness, hemoptysis, nausea/vomiting, diarrhea, abdominal pain, myalgia, rash, and dysfunctions of taste and smell. Severe symptoms may be observed, such as shortness of breath, respiratory failure, and death from viral pneumonia. However, some individuals may recover from this disease with mild symptoms such as nasal congestion and smell dysfunction, or with no symptoms at all.[5-7]

Due to the contagious nature of this virus, healthcare workers are among the most vulnerable groups. Dentistry practices pose a higher risk for dentists and residents due to the intensive generation of aerosol, very high viral load in the saliva of the infected individuals, and close face-to-face contact with patients during treatment.[4] Studies have demonstrated that the coronaviruses remain viable and contagious for several days on surfaces.[8,9] In addition, aerosols, especially from infected individuals, pose a significant risk of cross-infection in closed areas, even when social distance is maintained.[10] Accordingly, the Republic of Turkey Ministry of Health COVID-19 Scientific Advisory Committee defined the dental emergency practices and recommended that other non-urgent treatments be postponed, as of April 2020.[11] In this context, some orthodontists only performed emergency treatments, while others completely closed their clinics.

Dental emergencies have been identified in most countries. However, there is a deficiency regarding the orthodontic treatments addressed in these regulations. Emergencies are less common in most patients undergoing orthodontic treatment; however, orthodontists need a guideline on emergency care.[12] Orthodontic treatments last a minimum of 1.5-2 years, and patients are required to visit their orthodontists for monthly routine checks during this period. During the pandemic, follow-up sessions of orthodontic patients could not be performed due to the closure of some clinics.[13] During this period, orthodontic patients experienced various problems such as bracket failure, soft tissue irritation, and incompatibility of appliances. However, the problems could not be addressed for a long time due to the inability to undergo the necessary treatments.[14] This caused anxiety and stress in orthodontic patients.[15] Understanding the impact of the pandemic on orthodontic treatments may affect the future implementations of orthodontic practice. The aim of this study is to determine the difficulties experienced by patients receiving orthodontic treatment during the COVID-19 pandemic and to evaluate the problems experienced by orthodontic patients, along with their attitudes toward these problems.

METHODS

The study was approved by the Clinical Research Ethics Committee of Aydın Adnan Menderes University, Faculty of Dentistry (2021/05). The size of the sample was calculated using an online calculator, www.raosoft.com/samplesize.html. The survey study aimed to reach 1403 individuals. The required sample size was calculated to be a minimum of 302 with a 5% margin of error and a 95% confidence interval. Before sending out the questionnaire to the participants, a pilot study was conducted by sending it to a small group of approximately 20 orthodontic patients, in order to evaluate the clarity of the questions, the required time, and validity. An open-ended option was added to the end of each question, where the participants could add additional responses where necessary. Next, the questionnaire was modified accordingly and finalized. These questionnaires were not included in the total number of samples in the study.

This questionnaire was administered to patients whose orthodontic treatment had started and had been ongoing before the pandemic in 1 public clinic and 2 private clinics. The survey was uploaded to a website, and the link was sent to 1403 patients via SMS. All participants were informed that participation in the survey was voluntary and that they could stop responding to the questionnaire at any time. The survey was conducted anonymously to preserve the privacy of the participants. All data obtained were recorded on a researcher's computer and their confidentiality was ensured. Responses were received over a period of 3 weeks. The survey was answered by 502 orthodontic patients.

The questionnaire was developed in accordance with CHERRIES (Checklist for Reporting Results of Internet E-Surveys).[16] There were 23 questions in 4 sections of the survey. In the first section (questions 1-4), information was collected about the demographic characteristics of the participants, such as age, gender, and education level. The second section (questions 5-7) contained questions about symptoms of COVID-19, modes of transmission, and prevention methods. The third section (questions 8-19) consisted of questions regarding the extent to which the orthodontic treatments of the participants were affected during the pandemic, whether follow-up sessions were realized, and the conditions under which they consulted with the orthodontist. In addition, this section contained questions about whether orthodontic treatments were urgent, or what orthodontic emergencies were, according to the participants, whether they were worried about orthodontic treatment processes during the pandemic, and their concerns about the treatment processes. The fourth section (questions 20-23) involved questions about whether there were differences in the participants' oral hygiene and eating habits during the pandemic.

Statistical Analysis

The data of the study were compiled using Microsoft Office Excel 2007 (Microsoft, Reymond, WA, United States). The data were analyzed using the Statistical Package for Social Sciences (SPSS) software for Windows (version 21.0; IBM Corp., Armonk, NY, USA).

Table 1. Demographic characteristics of samples

	Public Clinic Patients, n (%)	Private Clinic Patients, n (%)	Total, n (%)
Age			
12-18	279 (72.1)	73 (63.4)	352 (70.1)
19-24	77 (19.9)	29 (25.2)	106 (21.1)
25-34	20 (5.2)	6 (5.2)	26 (5.1)
<34	11 (2.8)	7 (6.1)	18 (3.6)
Gender			
Female	230 (59.4)	61 (53.1)	291 (58)
Male	157 (40.6)	54 (46.9)	211 (42)
Education status			
Primary School	3 (0.8)	-	3 (0.6)
Secondary School	49 (12.7)	16 (13.9)	65 (12.9)
High School	254 (65.6)	74 (64.3)	328 (65.3)
University	72 (18.6)	22 (19.1)	94 (18.7)
Postgraduate	7 (1.8)	3 (2.6)	10 (0.2)
Appliance			
Fixed appliance	334 (86.3)	104 (90.4)	438 (87.2)
Removable appliance	53 (13.7)	11 (9.6)	64 (12.7)
Total	387 (77.1)	115 (22.9)	502 (100)

RESULTS

With the participation of 502 people in the survey, a response rate of 35.7% was obtained. The demographic characteristics of the participants are presented in Table 1. There were 291 females (58%) and 211 males (42%) among the 502 participants. Most of the participants were between 12 and 18 years of age (352, 70.1%), and 77.1% (387) had been undergoing treatment in a public clinic. The descriptive statistics regarding the second part of the questionnaire are presented in Table 2.

Table 2. Descriptive statistics of responses to section 2

Question	Item	Total, n (%)
Which one/ones do you think are among the symptoms of COVID-19?	Cough	395 (78.7)
	Joint pain	299 (59.6)
	Fever	427 (85)
	Eye redness	94 (18.7)
	Throat ache	298 (59.4)
	Numbness in hands and feet	78 (15.5)
	Nausea	113 (22.5)
Which one/ones do you think are the ways of COVID-19 transmission?	Surface pollution	335 (66.7)
	Via droplet	378 (75.3)
	By air	418 (83.3)
	None	7 (1.4)
	All	277 (55.2)
Which one/ones do you think are the ways of protection from COVID-19 infection?	Social isolation	451 (89.8)
	Wearing mask	478 (95.2)
	Using gloves	359 (71.5)
	None	5 (0.9)
	All	344 (68.5)

According to the results, 97.3% (372) of the patients in the public clinic, and 71.1% (79) of the patients in the private clinics had not been able to continue their treatment for 2 months or longer. Of the participants, 81.4% (367) were not able to attend the follow-up sessions due to the closure of the clinic where they had been treated. Of the patients who experienced problems or required information during the pandemic, 84% (95) of them in the private clinics and 77.8% (291) of them in the public clinic contacted the orthodontist at least once. The descriptive statistics of the third section, which were related to orthodontic treatment processes during the pandemic, are presented in Table 3. The participants were divided into 2 groups according to whether they were treated in the public or the private clinic. Most of the participants were concerned about extended treatment duration (349, 69.5%) during this period.

The problems faced by the participants receiving fixed orthodontic treatment and removable appliances are displayed in Figures 1 and 2, respectively. While the most common problems in patients with fixed appliances were soft tissue irritation (230, 52.5%), bracket failure (142, 32.4%), gingival swelling (88, 20.1%), and pain (88, 20.1%); patients with removable appliances indicated problems with new spaces between teeth (41, 64.1%), pain (37, 57.8%), and gingival swelling (29, 45.3%).

The descriptive statistics regarding the fourth section of the survey are presented in Table 4. While 60.7% (300) of the participants stated that there was no change in their brushing habits, 25.1% (124) stated that their brushing habits increased as they paid more attention to hygiene during this period, and 14.1% (70) stated that there was a decrease in their brushing habits.

DISCUSSION

The coronavirus outbreak has significantly impacted access to healthcare worldwide. Despite the fact that orthodontic practice generates less aerosol compared to other dental treatments, aerosols are generated in procedures such as bonding brackets and bands, while removing residual adhesives during the removal of the appliances, and during attachments in treatment with clear aligners. In addition, saliva droplets may splash during the insertion or removal of orthodontic ligatures and wires. Similar to other dental treatments, orthodontic practice has been affected by the pandemic due to the high exposure of orthodontists and the risk of cross-infection from patients. Significant problems have been experienced regarding the patients' orthodontic treatment.[13,17,18] Therefore, evaluating the effect of the pandemic on orthodontic practice is important in terms of mitigating these effects. This study is one of the first studies to evaluate the knowledge of patients undergoing orthodontic treatment during the COVID-19 pandemic, the problems they experienced regarding the treatment processes during this period, and their attitudes toward them.

Table 3. Descriptive statistics of responses to section 3

Question	Item	Public Clinic Patients, n (%)	Private Clinic Patients, n (%)	Total, n (%)
How often were your orthodontic checks performed during the pandemic period?	My appointments continued monthly	10 (2.6)	32 (28.8)	42 (8.5)
	1-2 months	104 (27.2)	44 (39.6)	148 (30)
	More than 2 months	131 (34.2)	29 (26.1)	160 (32.4)
	I had no control during this period	137 (35.8)	6 (5.4)	143 (29)
What was the reason for discontinuation of your orthodontic treatment?	The clinic was closed	198 (53.2)	50 (63.2)	248 (55)
	I was afraid of going to the clinic due to the epidemic	76 (20.4)	8 (10.1)	84 (18.6)
	For both reasons	98 (26.3)	21 (26.6)	119 (26.4)
How many times have you communicated with your orthodontist during this period?	I have never communicated	83 (22.2)	18 (15.9)	101 (20.7)
	1 or 2 times	175 (46.7)	59 (52.2)	234 (48.2)
	3 or 4 times	75 (20.3)	24 (21.3)	99 (20.3)
	More than 4	41 (10.9)	12 (10.6)	53 (10.8)
How did you communicate with your orthodontist?	Voice call	291 (75.3)	19 (16.5)	310 (61.7)
	Mobile phone application	10 (2.5)	61 (53.1)	71 (14.1)
	Calling and application	31 (8.0)	29 (25.2)	60 (12)
	SMS	55 (14.2)	6 (5.2)	61 (12)
What was your main concern about your orthodontic treatment process during this period?	My teeth conditions will relapse	128 (33)	38 (33.1)	166 (33.1)
	Treatment duration will be extended	268 (69.2)	80 (69.5)	349 (69.5)
	My orthodontist will be very busy during this period and will not be able to spare the necessary time for my treatment	59 (15.2)	16 (13.9)	75 (14.9)
	All	42 (10.8)	13 (11.3)	55 (10.9)
	I have no worries about my treatment process	59 (15.2)	21 (18.2)	80 (15.9)
To what extent do you agree / disagree with the closure of dental clinics to minimize the spread of the Covid-19 outbreak?	I absolutely agree	51 (13.5)	22 (19.4)	73 (14.8)
	I agree	64 (16.6)	17 (15)	81 (16.3)
	I partially agree	91 (23.9)	19 (16.8)	110 (22.2)
	I am indecisive	83 (21.4)	24 (21.5)	107 (21.5)
	I do not agree	64 (16.5)	17 (15)	81 (16.2)
	I strongly disagree	31 (8.1)	14 (12.3)	45 (9)
Have you followed all the instructions given by your orthodontist, such as using elastics or maintaining oral hygiene?	Yes, I did regularly	266 (71.5)	79 (70.5)	345 (71.2)
	Sometimes it is not very regular	102 (27.4)	31 (27.6)	133 (27.4)
	No, I could not pay attention	4 (1.1)	2 (1.9)	6 (1.4)
Have you experienced any emergency situation such as pain, swelling?	No, I have not had any problems	290 (77.1)	89 (78.7)	379 (77.5)
	Yes, I had a problem. I contacted my orthodontist	55 (14.6)	17 (15.2)	72 (14.8)
	Yes, I have, but I self-medicated	31 (8.3)	7 (6.1)	38 (7.7)
Do you think orthodontic treatment should be seen as an emergency?	Yes, because it can impair the final result	180 (47.2)	46 (40.3)	226 (45.6)
	Yes, some conditions such as pain, swelling, bracket failure, and soft tissue irritation should be considered urgent	140 (36.7)	48 (42.1)	188 (38)
	No, orthodontic treatments are not an emergency as they are not vital	62 (16.1)	20 (17.6)	82 (16.4)
What do you think about going to your orthodontic treatment appointments during the pandemic period?	I will go to my appointments regularly	317 (83.2)	101 (87.8)	418 (84.2)
	I prefer to go to my appointments less often	61 (16)	14 (12.2)	75 (15.1)
	I will not go until the pandemic is all over	3 (0.8)	-	3 (0.7)
Are you afraid of going to the clinic for your orthodontic treatment during this period?	Yes, I am afraid	161 (42.8)	45 (39.1)	206 (41.9)
	No, I am not scared	191 (50.7)	63 (54.7)	254 (51.7)
	Partly, I am worried	24 (6.5)	7 (6.2)	31 (6.4)

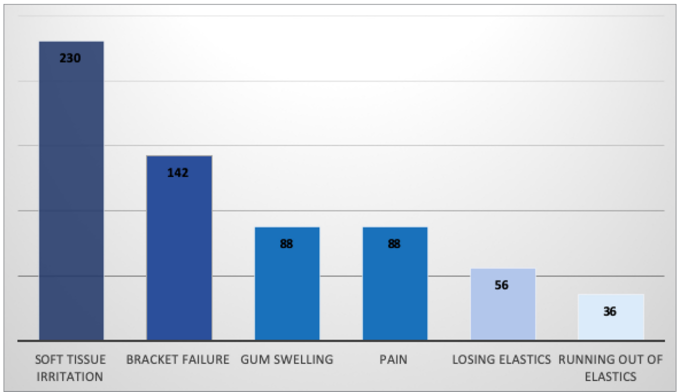

Figure 1. The problems faced by the participants receiving fixed orthodontic treatment.

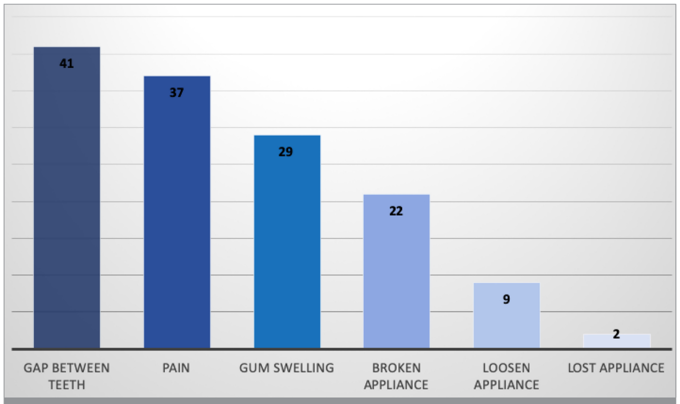

Figure 2. The problems faced by the participants receiving orthodontic treatment with removable appliances.

Patients undergoing fixed orthodontic treatment during the pandemic experienced more problems than patients undergoing removable orthodontic treatment. In fixed treatment, soft tissue irritation due to bracket failure was the most common problem. On the other hand, the most common problem with removable appliances was the incompatibility. This result of the study was found to be consistent with the results of similar previous studies.[19-21] In the present study, the problem of bracket failure that was encountered frequently in patients undergoing fixed orthodontic treatment may have occurred due to disregard of the nutritional warnings given by their orthodontist. In addition, the presence of gingival swelling was a common response in patients undergoing fixed and removable orthodontic treatment. Gingival swelling accompanies a lack of oral hygiene, and patients' motivation to ensure oral hygiene may have decreased during the pandemic.[22]

The orthodontic treatment was interrupted during the pandemic for the vast majority of patients in the present study. Most of these patients had been undergoing treatment in the public clinic, and the main reason for the inability to access treatment was the closure of the clinic. This could be justified by the mandatory decision of the government to close the universities. In guidelines and scientific articles, it was recommended that patient appointments be rescheduled and only emergency cases be treated during the COVID-19 pandemic.[14,18,23] In the current study, the majority of the patients treated in private clinics presented only for emergency treatment, as recommended. On the other hand, most of the patients were willing to continue their routine orthodontic treatment despite the recommendations. The participants stated that they had sufficient information about the symptoms of COVID-19 and transmission routes. This may have been due to the inability of the patients to understand the severity of the pandemic, or due to their concern about the treatment processes. Most of these patients believed that their orthodontic treatment would be extended due to the COVID-19 outbreak. This may have been caused by the concern that the quality of treatment would deteriorate due to insufficient information about the progress of their treatment. A greater proportion of patients were concerned about extended treatment durations rather than the recurrence of orthodontic treatments. This result was consistent with the results of the previous studies.[19,21]

Face-to-face interaction is at the core of healthcare services; however, it is recommended that the emergencies should be

Table 4. Descriptive statistics of responses to section 4

Question	Item	Total, n (%)
Did your brushing habits change during the pandemic period?	There was no change	300 (60.7)
	My brushing habits increased	124 (25.1)
	My brushing habits decreased	70 (14.1)
How often did you brush your teeth during the pandemic period?	I brushed 3-4 times a day	195 (39.5)
	I brushed 1-2 times a day	269 (54.6)
	Sometimes I forgot and never brushed	29 (5.8)
Did you pay attention to the recommendations of your orthodontist about nutrition such as acidic drinks and solid foods during the pandemic period?	Yes, I have always taken care	218 (44.3)
	Sometimes I could take care	248 (50.4)
	No, I could not take any care	26 (5.3)
During this period, did you experience any problem such as bracket failure or soft tissue irritation due to not complying with the nutritional recommendations of your orthodontist?	No, there was no problem	309 (63.9)
	Yes, 1-2 instances of bracket failure	165 (34.2)
	Yes, there was frequent bracket failure, and the elastics came off	9 (1.9)

primarily managed remotely during the pandemic. In some cases, patients or parents can solve problems at home with guidance. For this purpose, orthodontists can send out the informative photos and videos they prepare or that are available on their websites. In addition, they can provide their patients with access to materials such as aligners, orthodontic wax, and elastics in order to ensure that their treatment is not interrupted.[13]

In fact, continuous evaluation by the orthodontist is necessary to evaluate the effectiveness and undesirable effects of orthodontic treatment. Nonetheless, some periodic visits are not absolutely necessary, and instructions can be provided on how to modify the appliances. Recently, an innovative approach has been proposed in the field of medicine. Telemedicine was initially developed to provide healthcare services in remote areas; however, healthcare services are beginning to be provided via video calls over the internet to patients who are not able to access healthcare institutions, or who avoid visiting them during the pandemic.[24] Telemedicine, which is used to reduce the spread of contagious disease and ensure more effective employment of healthcare personnel, facilitates access to healthcare services during the pandemic. The limitations of remote healthcare services and the problems they may cause should not be overlooked. According to the declaration of the World Medical Association about telemedicine practices, attention should be paid to the confidentiality of patient data, and informed consent should be obtained for the distinctive features of telemedicine practices.[25] Accordingly, scientific standards of e-health applications should be determined, and implementation guides should be created in order to protect patient and physician rights as well as the patient–physician relationship.

Orthodontists and dental assistants should take care to communicate effectively with patients in order to increase mutual trust and provide information.[26] In this context, teleorthodontics and other technologies can be utilized in emergency situations as an alternative to face-to-face communication. Phone calls, live video/teleconferencing, text messages on WhatsApp or social media, and e-mails can improve communication between the orthodontist and the patient.[27] Thus, this care and contact with patients can increase the confidence in the orthodontist, and reduce the anxiety and stress related to the orthodontic treatment process in patients. Moreover, it is known that of the factors contributing to patient satisfaction, the most important is the patient–physician relationship.[28] In the current study, most of the participants tried to communicate with the orthodontists in different ways. While the patients undergoing treatment in the public clinics mostly communicated by phone, the majority of patients undergoing treatment in private clinics accessed their orthodontist via mobile applications. Patients undergoing treatment in private clinics may have preferred the mobile application since they were able to display the problems they encountered more easily through pictures instead of describing them.

A web-based questionnaire was used in this study due to the restrictions during COVID-19. The questionnaire was sent out to all patients undergoing treatment in the clinics where this study was conducted; however, the possibility of selection bias should also be considered. Moreover, the number of participants was relatively small; therefore, surveys with larger sample sizes can produce more generalized results.

CONCLUSION

Orthodontic treatments were impacted significantly and disrupted by the COVID-19 pandemic, and most patient appointments were delayed. Patients experienced various problems with their treatment, and as a result, concerns about delay of treatment increased. Therefore, orthodontists should pay more attention to teleorthodontics during the pandemic process.

Ethics Committee Approval: Ethical committee approval was received from the Clinical Research Ethics Committee of Aydın Adnan Menderes University, Faculty of Dentistry (2021/05).

Informed Consent: Informed consent was obtained from the patients who agreed to take part in the study.

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Review

Guidelines of Revised Orthodontic Practices for Establishing "New Normality" Post COVID-19 Pandemic

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Main Points

- Embracing the environmental modifications such as the use of high volume evacuation systems, drying of dental unit waterline, and procedural modifications such as the use of resin-modified glass ionomers (RMGIC) and lasers will help us to obtain a more disease-free environment.
- New categorization of orthodontic emergencies helps us to delineate the necessary procedural modifications.
- Incorporation of procedures such as pre-orthodontic screening and post-orthodontic clean-up aids to prevent and protect the spread of the infection.

ABSTRACT

The aim of this article is to shed light upon formulation of new guidelines of revised orthodontic practices in the post-pandemic era caused due to the novel coronavirus disease 2019 (COVID-19) and also to adapt to the new regulations to prevent further spread of infection. All relevant information pertaining to the area of concern was collected using electronic databases which include Google Scholar, PubMed, Cochrane, orthodontic journals, and health bodies such World Health Organization, the British Orthodontic Society, and the National Institute of Health. Post-pandemic visionary was also contemplated. Data collected through the electronic databases were studied and compiled to provide an overview of the possible modifications which could be employed to prevent cross-contamination during and after the orthodontic therapy in the -post-pandemic era. Refashioning of the dental set-up along with the formulation of new regulations have been elucidated. This review highlights that the post-pandemic orthodontic practice is a divergent layout requiring tedious clinical and environmental modifications. New categorization of patients requiring orthodontic treatments and procedural classification based on generation of aerosol must be taken into consideration. Formulation of new regulations and redesigning the clinical set-up is crucial yet essential.

Keywords: New normality, post-pandemic, dentistry, orthodontics, COVID-19

INTRODUCTION

The year 2020 has been marked distinctly by the pandemic outbreak of the coronavirus disease 2019 (COVID-19) caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). As per current reports, the disease was reported first in Wuhan, China in December 2019.[1-3] However, the clear-cut data regarding how, when, and where this disease originated is still disguised. The COVID-19 virus has spread rapidly and has left behind an indelible scar in many places throughout the world. It has led to global health, humanitarian, and financial crisis owing to a public health emergency catastrophe of international concern.

According to current evidence, the COVID-19 virus is primarily transmitted between people through respiratory droplets.[2] Considering this fact, dentists are at the highest risk for exposure to this virus since the

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saliva and aerosols along with splatter aids the spread of the virus. As orthodontists consult many patients on a single day with long and continuous treatment procedures, effective prevention of the novel coronavirus is more strenuous. Owing to the extended treatment procedures and children comprising the majority of the orthodontic patients, strict infection control measures have to be followed for an efficient orthodontic practice. A number of preventive measures such as usage of personal protective equipment (PPE), decontamination of the office, and training of the orthodontic team in sterilization and disinfection protocols play a major role in infection control.[4] As Sir Albert Einstein rightly said, "In the middle of difficulty lies opportunity," the crisis should be considered as a good time to formulate new protocols and adapt them in our daily practice. This new adaptation is solely the "new normality" that fortifies us and others from the novel coronavirus. The aim of this article is to shed light upon the formulation of new guidelines of revised orthodontic practices in the post-pandemic era caused due to the novel coronavirus disease 2019 (COVID-19) and also to adapt to the new regulations to prevent further spread of infection.

METHODS

A broad selection of all relevant articles pertaining to the pandemic and its effects on the orthodontic practice was obtained from electronic search engines such as Google Scholar, PubMed, Cochrane, orthodontic journals, and health bodies such World Health Organization, the British Orthodontic Society, and the National Institute of Health. All articles regarding the orthodontic procedures at menace and its possible substitutions were also identified in a similar manner. The entire collected data were analyzed thoroughly to obtain all the relevant information. Orthodontic emergencies which could arise during the pandemic were also evaluated using various studies and surveys in the literature and were aggregated to pick out the frequent ones. Solutions to these emergencies and substitutions to different procedures and materials were identified and agglomerated in this article.

RESULTS

Orthodontic procedures are regarded as less life-threatening until it loses cohesion. Hence, many articles were directed toward emergency orthodontic management during the pandemic. Many such procedures could also be adopted in the post-pandemic aeon. Nevertheless, the need for embracing new categorization and revamping the clinical procedures is obligatory. The etiological and preventive aspects of the COVID-19 pandemic have been explained vastly in the literature. Few articles were also identified pertaining to the emergency arising during the pandemic situation.[5,6] Nevertheless, the exact technique in substituting orthodontic procedures by employing clinical modifications and procedural modifications was not identified. Hence, this article has been formulated to elaborate the implications of possible modifications which could be employed during the pandemic situation and in the post-pandemic era as well.

DISCUSSION

Classification of Orthodontic Procedures

Orthodontic treatment procedures can be classified into aerosol-generating procedures (AGPs) and non-aerosol-generating procedures (NAGPs).

Aerosol-generating procedures include:

- High-speed air rotor drills including surgical drills
- Slow-speed drills, run wet and dry, including surgical drills
- 3-in-1 spray
- Ultrasonic and sonic handpieces for scaling
- Air-abrasion or intra-oral sandblasting for recycling brackets

Non-aerosol-generating procedures include:

- Replacing archwires
- Activation of intra-oral appliances
- Changing elastomeric chains and elastic
- Review for functional and orthopedic appliances

Aerosol-generating procedures can be substituted by alternative methods wherever possible. However, in cases wherein an alternative approach is not possible, then a separate room set-up for carrying out AGPs would be of great importance. Hence it would be wiser to have 2 separate rooms to practice AGPs and non-AGPs separately and a separate room for donning and doffing. In total, 3 rooms apart from the reception area are essential (Figure 1).

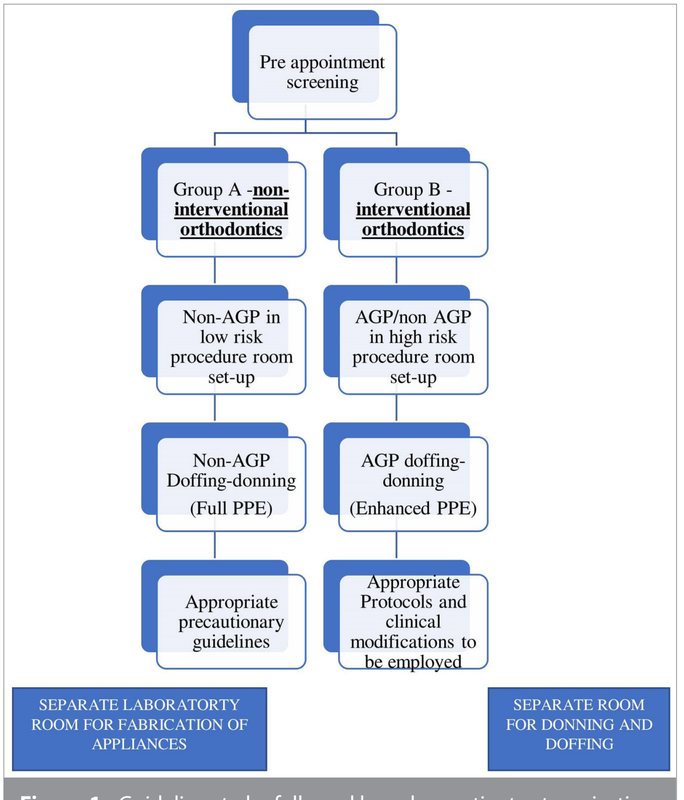

Figure 1. Guidelines to be followed based on patient categorization

Classification of Orthodontic Patients

Patients seeking orthodontic therapy can be newly categorized under the following 2 categories:

(A) Non-interventional orthodontics and passive orthodontic appliances
(B) Interventional orthodontics and active orthodontic appliances

Non-interventional Orthodontics and Passive Orthodontic Appliances

This category includes patients requiring monitoring of tooth eruption and dental arch development with the following procedures to be addressed:

- Periodic orthodontic reviews/Dental check-ups
- Passive appliances and interventions involving the use of the following: holding or space maintenance, habit-breaking appliances, etc.
- Serial extractions
- Retention appliances

In these patients, NAGPs can be carried out with appropriate PPE and disinfection guidelines.

Interventional Orthodontics and Active Orthodontic Appliances

This category includes patients requiring monitoring of tooth eruption and dental arch development with the following procedures to be addressed:

- Dentofacial orthopaedic appliances
- Functional appliances
- Fixed appliance Mechanotherapy (including adjunctive mechanical aids)
- Aligner therapy

These patients require a high-risk procedure room set-up with stringent protocols and environment modifications as well as clinical modifications.

Personal Protective Equipment

Personal protective equipment including facial masks, face shields, eye protection, gowns, and gloves is essential protective gear for dental practitioners and assistants during consultations. However, the type of PPE worn during the treatment procedure can be altered. There are 3 basic types of PPE namely:

a) Standard PPE
b) Full PPE
c) Enhanced PPE

- Standard PPE can be recommended during pre-appointment procedures and in the reception area.
- Full PPE can be recommended for non-interventional orthodontics and passive orthodontic appliances using NAGPs and low-risk AGPs.
- For patients in need of interventional orthodontics and active orthodontic appliances with AGPs and high-risk NAGPs, enhanced PPE should be employed.
- In any types of PPE adopted, stringent protocols have to be followed for donning and doffing.

Revised Orthodontic Practices

In all of the above-mentioned categories, we intend to consider the following guidelines:

a) Screening and pre-appointment
b) Clinical modifications
c) Post-consultation

Screening and Pre-orthodontic Procedures

Appointments for orthodontic purposes can be obtained through a digital platform using the hospital's website/through phone calls. Primary consultation can be performed through video calling by making use of portals such as zoom/google meet/doxy.me. Emergency cases also should be given appointments and walk-in should be avoided as much as possible. Patients must not be encouraged to bring other family members with them except for children who can be accompanied by 1 parent.

Upon patient's arrival, the dental hygienist/receptionist greets the patient and instructs them to wash their hands or use hand sanitizer. The patient is then advised to remain in the waiting area. The need for history taking is inescapable and hence a COVID 19 disclosure/consent form becomes mandatory. Digital copies of the forms are more preferable thus preventing cross-contamination. The form should include all but not limited to the following questions:

1. History of fever (37.3°C or higher) or use of antipyretic medication in the past 14 days.
2. Symptoms of lower respiratory tract infection including dyspnea in the past 14 days.
3. History of travel to a COVID-19 epidemic area in the past 14 days.
4. History of contact with a confirmed COVID-19 in the past 14 days.

The body temperature of the patient has to be checked using a thermal scanner. Infra-red sensors have proven to be more effective since it records the core body temperature rather than the superficial skin temperature. Pulse oximeters are being a vital tool to check the oxygen saturation levels before starting the procedure. Patients in the waiting area must be insisted to maintain social distancing.

Upon examination, if the patient is suspected asymptomatic then the appointment is rescheduled and the patient is advised to self-quarantine themselves at home for 14 days. If the patient is asymptomatic, further clinical procedures can be carried out. Mouth rinse before any procedure using 0.12% to 0.2% chlorhexidine gluconate could help minimize the number of microbes

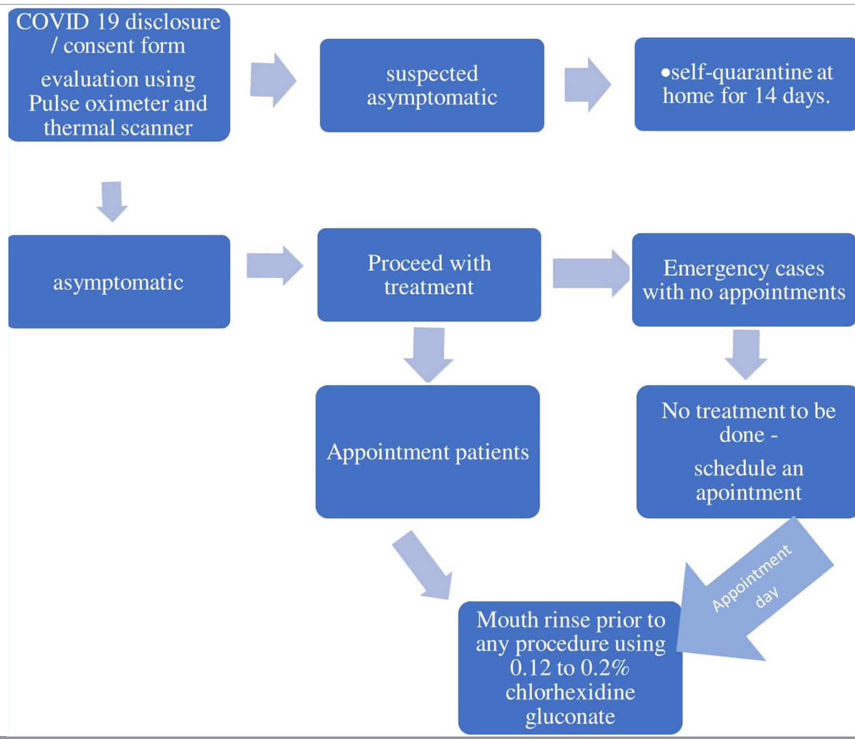

Figure 2. Pre-orthodontic preparation protocols

within the oral cavity (Figure 2). Previous studies have shown that oxidizing mouthwashes reduce the viral load and the nasopharyngeal microbiota thus acting as a valuable adjunctive therapy.[7]

Clinical Modifications

Orthodontic clinical modifications have to be adapted to reduce the risk of aerosol contamination. These modifications have to be employed in and around the working area which is called environmental modification. The orthodontic procedures which have been followed for a long time also have to be modified which is referred to as procedural modifications.

Environmental Modifications

The working area remains to be a hub for infectious organisms to laden. Specifically, electronic gadgets are given the least care for disinfection. Prescribing drugs for patients using prescription pads remains customary especially in the developing countries. These are a few inconspicuous areas wherein thorough decontamination is obligatory.

Cordless electrostatic sprayers are available for hands-free disinfectant application which can be used for decontamination of the working as well as non-working areas. Intra-oral and extra-oral aerosol evacuation systems must be installed to protect the operatory from airborne contaminants. Various extra-oral mobile high-volume evacuation (HVE) systems are available in the market which helps in close-to-the-mouth evacuation of the aerosols. Combining extra-oral HVE systems and intra-oral low-volume evacuation (LVE) systems can be more rewarding.

The following are the key environmental modifications to be adhered to:

- Decluttering of working slabs
- Computers screens, mousepads, keyboards, light cure units, instrument trays, headrest, chair light, suction tubes, etc. should be covered with barrier films.
- Printed prescriptions are preferred over handwritten prescription pads.
- At least 3-4 sets of instruments such as distal end cutters, archwire cutters, pin, and ligature cutters, Light arch pliers, and Mathews forceps must be packed individually and made available.
- Air purifier with a high-efficiency particulate air (HEPA)-14 must be available in the room.
- A combination of extra-oral and intra-oral evacuation systems to be installed

Procedural Modifications

Various clinical procedures and materials which are being acted in accordance with have to undergo a few modifications to lower the risk of infection and cross-contamination (Figure 3). The procedures which are at risk include:

- Impression taking
- Banding
- Bonding/Re-bonding
- Debonding
- Plaque removal
- Acrylic appliances
- Extractions

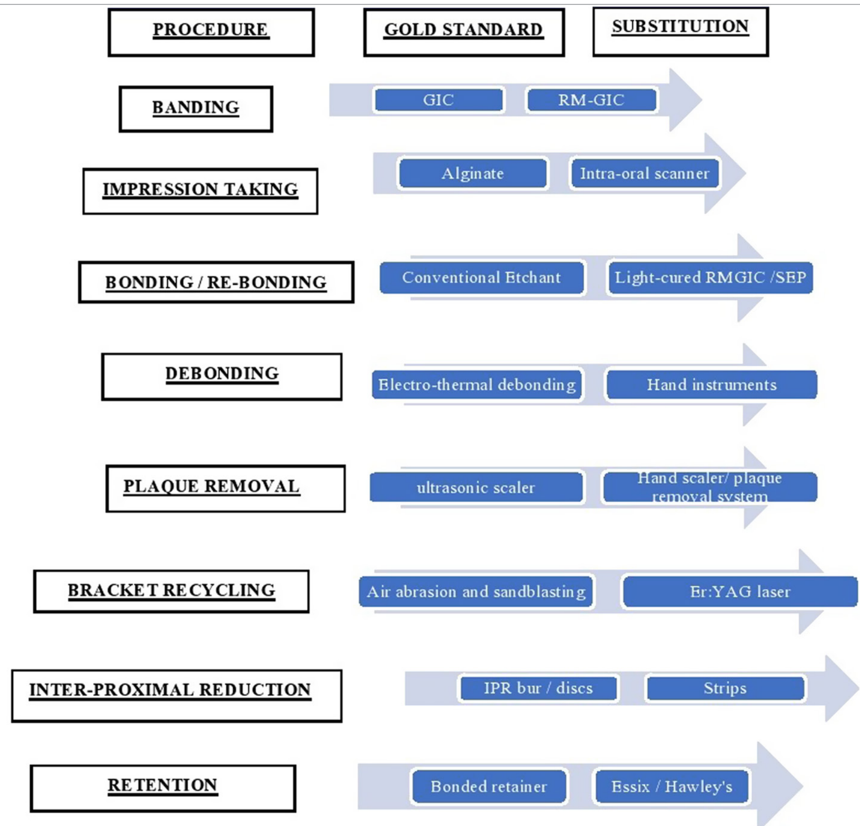

Figure 3. Modified orthodontic procedural management

- Inter-proximal reduction
- Retention

Impression Taking

Although the present era is for digital therapy using computer-aided designing and computer-aided manufacturing (CAD-CAM) aligners, practical considerations for complete aligner therapy for all the patients are not possible due to the financial considerations of the majority of the population. However, the impression-taking procedure can be performed digitally using intra-oral scanners. The conventional impression taking provokes gag reflex as well as cough in certain individuals thereby mediating the spread of infection to longer distances. The goop and gag being the main disadvantages of the conventional impression making, the acceptance, and comfort especially in young orthodontic patients is higher with digital impressions.[8] Students also reported preference for the digital technique and hence implementing digital intra-oral impression technique into undergraduate training is recommended.[9]

Banding of Molars

In routine clinical practice, direct bonding of the anterior teeth is followed. However, molars are often banded considering the fact that the failure rates are lower than that of bonded attachment and taking into account the anchorage demand.[10] Although zinc phosphate was used initially, glass ionomers are currently in practice because of their antimicrobial activity and fluoride release.

Recently, resin-incorporated glass ionomers (GIC) creating "hybrid" cement are more preferred because of its decreased moisture contamination and increased strength. Resin-modified glass ionomers (RMGIC) setting through an acid-base reaction, with or without polymerization have also proved to prevent enamel demineralization adjacent to orthodontic bands.[11] Hence, the usage of RMGIC is preferred over conventional GIC for the banding of molar teeth. RMGIC is also available in a self-adhering paste system in a convenient automix syringe which offers ease of application.

Bonding/Re-bonding

Bonding in orthodontics is an unavoidable procedure with the exception of aligner therapy. Nevertheless, the technique and appliance of choice can be altered. Light-cured resin-modified glass ionomer cement can be used without any prior enamel preparation such as polishing, etching, or drying since this reduces the need for an absolutely dry field. Self-etch primers can also be used without prior enamel preparation and etching, but they require the smear layer to be removed before use, usually by pumicing or polishing teeth, which would be categorized as an AGP. A dry cotton roll/chip blower to clean the enamel surface instead of a 3-way syringe serves as a good alternative.

Indirect bonding is another alternative method that could be employed. However, the flash removal must be performed with utmost caution. Self-ligating brackets are a good replacement for conventional brackets offering better hygiene since the elastomeric ties are avoided and also offer fewer orthodontic visits reducing exposure to contaminants.

Gange[12] has proposed certain guidelines for orthodontic technique in JCO 2020 which can also be adopted.

Debonding

The use of high-speed air turbines with coolant water during the adhesive material removal increases the amount of aerosol contamination in and around the operatory area. Hence barrier equipment is necessary during debonding.[13] Aerosol particulates produced during enamel clean-up might be inhaled irrespective of hand-piece speed or the presence or absence of water coolant. These particulates will most likely deposit in the conducting airways and terminal bronchi of the lungs which will be cleared by the mucociliary escalator while some are likely to be deposited in the terminal alveoli and cleared after weeks or months.[14] Hence the usage of high-speed aerators must cease forthwith. Scraping of the adhesive remnant with a hand scaler serves as a valuable alternative.

Bakry et al.[15] in 2019 have invented a method for debonding orthodontic metal brackets with eugenol emulgel. It claims to reduce Vickers hardness of the dental resin thereby decreasing the debonding force and hence the throw of the remnants. Laser debonding is an effective alternative however the adhesive remnant index (ARI) did not show statistical significance in the remnant present after debonding. The amount of enamel damage was found to be lesser with laser debonding.

Grünheid et al.[16] studied the in vitro effects of elimination of the need to clean up excessive adhesive upon debonding of a new flash-free adhesive (APC Flash-Free Adhesive Coated Appliance System, 3M Unitek [3M], Monrovia, California, USA). It was concluded that the amount of adhesive remnant on the tooth surface was similar to the conventional adhesive. However, there was a noticeable trend toward shorter adhesive remnant clean-up time with the flash-free adhesive, despite a larger amount of adhesive remaining after debonding.[16]

Plaque Removal

Plaque deposition in patients undergoing orthodontic therapy is increased compared with non-orthodontic patients and is not influenced by age, gender, or duration of orthodontic treatment.[17] Conventionally, ultrasonic cleaners are used for plaque and calculus removal. In a pilot study, it was determined that the aerosol contamination during ultrasonic scaling was found on the head, chest, and inner surface of the face mask of the operator and the assistant. It was also determined that the aerosol was retained in the air for up to 30 minutes after scaling.[18]

Commercially available focused spray ultrasonic inserts promises to have lesser aerosol generation. However, this has to be combined with high-volume evacuators and adequate ventilation. A more cost-effective method to decrease aerosol generation is to use hand scalers for the removal of plaque and calculus.

Bracket Recycling

Bracket recycling can be done by chemical, thermal, or mechanical methods. It is generally carried out through the process of sandblasting using aluminum oxide or heating over a bunsen flame or a combination of both. This can also be followed by immersion of the brackets in an acid bath containing hydrochloric acid and nitric acid. Silica coating with aluminum trioxide particles followed by silanization is also a proven method for bracket recycling. All of these methods result in aerosol generation during recycling and hence they have to be carried out with utmost caution.

The use of erbium: Yttrium aluminum garnet (Er:YAG) laser was found to be the most efficient method for recycling followed by sandblasting, thermal, and tungsten carbide methods.[19] For ceramic brackets, both Er:YAG laser and sandblasting were found to be efficient with Er:YAG laser having the advantage of not changing the design of the bracket base while removing the remnant adhesive.[20] The shear bond strength of repeated recycled brackets using sandblasting was found to be the same and there were not many changes in the morphology of the bracket base/slot dimensions.[21] However, using lasers, there was incomplete removal of the adhesive from repeated recycled brackets along with flattening and distortion, and hence it is preferred to use a new bracket in case of second bond failure.[22]

Acrylic Appliances

Acrylic appliances should initially be cleansed thoroughly underwater and then disinfected using hydrogen peroxide or Corega tablets. Simple fitting and adjustments of the removable appliances are not classified as an AGPs and hence it does not need any special care.

Trimming of the acrylic appliance generates aerosol and hence it should be carried out in high-risk procedure rooms after decontamination. It should be performed using a slow-speed motor with caution since the acrylic particles act as a carrier for virus transmission. It is rinsed again before re-insertion.

Extractions and Disimpactions

Extractions especially for orthodontic purposes are unavoidable treatment procedures. They have to be carried out with maximum precaution. Single-visit extractions have been recommended to reduce patient exposure as much as possible.

Disimpaction of teeth involves surgical exposure of the impacted teeth followed by bonding of a bracket or an attachment to the exposed teeth. Disimpaction can be performed either as an open technique or a closed technique. Whichever technique is to be adopted; the above-mentioned bonding protocols must be followed strictly.

Clear Aligner Therapy

Clear aligner therapy stands a better place especially during the pandemic in being the orthodontic therapy that provides the least number of in-patient appointments.[23] It was determined from a questionnaire study that the fixed appliances produced major emergency conditions during the pandemic requiring tele-orthodontics.[24] It was determined that the Whatsapp web was considered a good method of communication for the patients during the pandemic.[25] To kick off with the digital impression making, the chairside time, and cross-contamination are majorly reduced with the aligners. A review by Kaur et al.[26] concluded that the clear aligner therapy offers a clear advantage over the fixed labial/lingual appliance distinctly during the pandemic. Nevertheless, it cannot be suited for all cases with some requiring fixation of auxiliaries such as attachments, intermaxillary elastics, etc.

Inter-proximal Reduction

Interproximal reduction using burs generates aerosol production and hence IPR strips should be used instead of burs and discs. Low-speed airotors can be employed as an alternative. However, they should also be carried out in a high-risk procedure room with maximum protection.

Retention

Orthodontic retention is one of the most important benchmarks in achieving successful treatment results. Usually, fixed lingual retainers are more preferable than removable retainers, especially in the mandibular arch. However, it has been suggested that both types of retainers are associated with gingival inflammation and elevated plaque scores. But the alignment is maintained in place better with fixed lingual retainers.[27]

Considering the current situation to reduce the contact time of the patient and prevent contamination, an Essix retainer, Hawley's retainer, or any other type of removable retainer is preferred over bonded lingual retainers. It is recommended to provide additional pairs of retainers to the patients to reduce patient exposure in case of loss or damage.

Use of Rubber Dam

In orthodontics, the usage of rubber dams is very limited. Previous studies have shown the application of rubber dam usage during debonding to prevent aspiration of the debonded fragments.[28] Now that it has been established that the coronavirus is said to be laden in the salivary glands for as much as 29 days, further use of isolation techniques using rubber dams especially during bonding can be further explored.

Post-orthodontic Clean-up

Post-orthodontic clean-up of the operatory is an important regimen to follow. Patients should be advised to leave the unit immediately after their appointment. The next appointment should be spaced effectively to allow time for sanitization and disinfection of the operatory. For floor disinfection, a 2 step cleaning procedure must be employed. Detergent and freshly prepared 1% sodium hypochlorite with a contact time of 10 minutes after any patient/ major splash or 2 hour to be done for the entire working area.

Freshly prepared 1% sodium hypochlorite before starting daily work, after every procedure and after finishing daily work on the rest of the surfaces. Delicate Electronic equipment should be wiped with an alcohol-based rub/spirit (60-90% alcohol) swab before each patient contact. For sterilization of orthodontic pliers, steam autoclave sterilization, ultrasound bath, and thermal disinfection or disinfection with chemical substances 2% glutaraldehyde or 0.25% Peracetic acid (PAA) can be done.

Orthodontic markers can either be autoclaved or disinfected using glutaraldehyde solution. Cleaning photographic retractors with a washer-disinfector is recommended. Flushing dental unit water lines for at least 2 minutes or using disinfectants improves the quality of water within the dental unit and minimizes the risk of infection. Numerous studies have demonstrated that mechanical methods such as the use of filters and drying of the dental unit waterline (DUWL) overnight are very effective mechanisms. Chemical methods such as the use of Dioxiclear and MicroCLEAR were found to be the most effective in treating the contamination.[29]

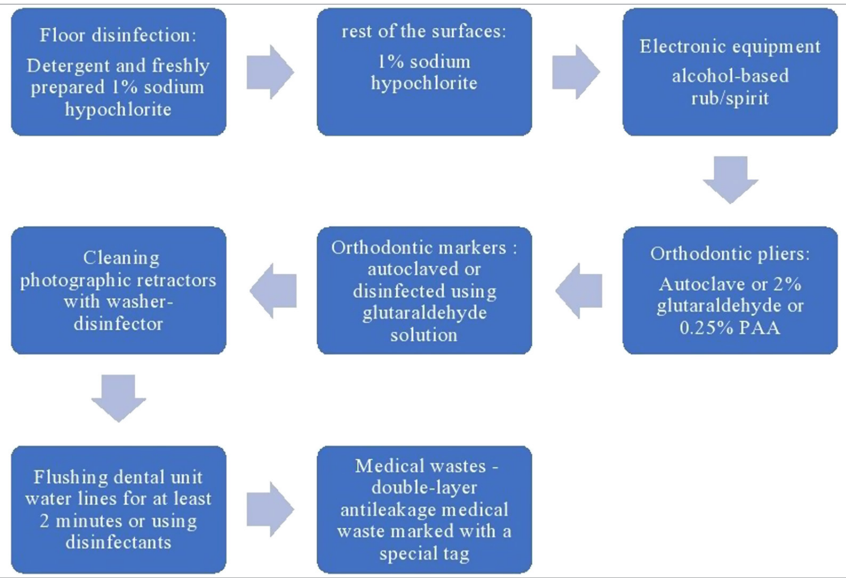

Figure 4. Post-orthodontic clean-up

Medical wastes should be handled as infectious medical wastes. A double-layer antileakage medical waste marked with a special tag is recommended (Figure 4).

CONCLUSION

Although symptomatic patients have been the main source of transmission, asymptomatic patients and patients in the incubation period still serve as carriers. Since the salivary glands act as a reservoir for the virus as long as 29 days after infection, the potential for the spread of infections from patients to dentists or dental assistants is high. Let us all remember that the circumstances are beyond control, but our conduct is in our own power. Thus, emphasis and commitment toward a strict protocol and adaptation to the “new normality” are mandatory for the prevention of the disease.

At the end of the day, the goals are simple: safety and security!

Let us all fight the virus together but not too close!

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