THE JOURNAL OF PROSTHETIC DENTISTRY

RESEARCH AND EDUCATION

Subjective qualitative assessment of the finish line of prosthetic preparations submitted to different finishing instruments

Tallita Foglietto da Silva, DDS, MSc,[a] Murilo Pereira de Melo, DDS, MSc,[b] Jefferson Ricardo Pereira, DDS, PhD,[c] Wilton Mitsunari Takeshita, DDS, PhD,[d] Bruno Mafra Ceribelli, DDS,[e] and Lilian Cristina Vessoni Iwaki, DDS, PhD[f]

ABSTRACT

Statement of problem. Different instruments have been developed to improve crown finish lines after conventional preparation with diamond rotary instruments. However, more evidence on the effectiveness of these instruments is required.

Purpose of study. The purpose of this in vitro study was to assess the effectiveness of 4 different instruments used for cervical margin finishing in regard to the external line angle (ELA).

Material and methods. Forty-eight freshly extracted third molar teeth with similar dimensions were conventionally prepared for crowns and randomly allocated into 4 groups (n=12) according to the finishing instrument: hand trimmer (HT), tungsten carbide bur (TCB), ultrasonic instrument (UI), and diamond rotary instrument (DRI) mounted in a contra angle handpiece with reduced speed. Photomicrographs from the margin profiles of each tooth were obtained with scanning electron microscopy (×40) before and after finishing procedures. The images were qualitatively analyzed (scores 1-4) by 9 experienced dental professionals. Average results were assessed with the paired *t* test and repeated measures ANOVA followed by Tukey HSD test (α=.05).

Results. HT, TCB, and UI demonstrated no significant differences between unfinished and finished mean ELA scores. DRI was the only group to demonstrate a significantly improved ELA (P<.001). Except for HT in relation to TCB (P=.989), all the other groups demonstrated statistically significant different ELA scores.

Conclusion. DRI mounted in a contra angle handpiece was the only finishing instrument capable of significantly improving the ELA, while TCB and UI produced nonsignificant improvement, and HT was detrimental to the ELA. (J Prosthet Dent 2016;116:375-381)

Dental crown cervical margin finishing is considered a critical stage in preparations for fixed prostheses, because it defines the fit of a restoration to the prepared tooth.[1] The long-term prognosis for fixed dental prostheses is directly related to clear, precise, and regular cervical margins.[1-3] Chipped and irregular finish lines may increase the risk of microleakage and secondary caries around the cementation line,[4,5] preventing the adequate maintenance of periodontal structures.[6,7] The cement may also wash out and caries is a risk. Moreover, a well-defined, sharp external line angle (ELA) without a lip of unsupported enamel facilitates the impression and fabrication of a precisely fitting restoration, contributing to a long-lasting, esthetic, and functional result.[8]

Comparative studies have demonstrated that the fit of porcelain crowns is a very sensitive technique.[9-11] Finishing and polishing of cervical margin preparations have been proposed in order to improve marginal fit.[12] However, finalizing the finish line is one of the most delicate stages in prosthetic preparations and, as a result,

[a]Graduate student, School of Dentistry, State University of Maringá (UEM), Maringá, Brazil.
[b]Associate Clinical Professor, School of Dentistry, State University of Maringá (UEM), Maringá, Brazil.
[c]Associate Clinical Professor, School of Dentistry, University of the South of Santa Catarina (UNISUL), Florianopolis, Brazil.
[d]Associate Clinical Professor, Department of Dentistry, Oral Diagnosis, Federal University of Sergipe, São Cristóvão, Brazil.
[e]Private practice, Maringá, Brazil.
[f]Associate Clinical Professor, School of Dentistry, State University of (UEM), Maringá, Brazil.

Clinical Implications

The most predictable external line angles of complete crown cervical margin preparations can be obtained with diamond rotary instruments mounted in a contra angle handpiece.

must be planned and executed carefully.[7,13] The adjacent structures involved in the procedure, such as the periodontium and the pulp, must be respected to avoid injuries.[7]

Different hand, rotary, and oscillating (ultrasonic) instruments have been developed in an attempt to improve finish line regularity after the conventional preparation with diamond rotary instruments. Contra angle handpieces with reduced speeds, which do not require adaptors, are now commercially available for rotary instruments, while new hand instrument designs, as well as diamond tips specifically designed for ultrasonic instruments, have also been introduced with the objective of refining preparations and improving the fit of prosthetic restorations.[4,7,8] Thus far, however, most studies on finish line preparations have concentrated on the assessment of the surface roughness of the axial wall/marginal angle or the margin surface of the teeth.[9-17] While smooth, well-defined, and rounded axial wall/margin angles are important, particularly for bonding procedures, little attention has been given to the ELA.

The objective of this in vitro study was to assess the effectiveness of 4 different instruments used for cervical margin finishing in regard to the ELA. The null hypothesis was that the ELA would not be significantly improved by using any of the finishing instruments tested.

MATERIAL AND METHODS

Four experimental groups were established, in which the instrument used to improve the cervical margin finish line was considered as the study variable. Scanning electron microscopy (SEM) images were analyzed by 9 experienced professionals, who rated crown preparations both finished and unfinished. The in vitro study was approved by the Institutional Review Board of the State University of Maringá (UEM), Brazil (protocol No 16292113.2.0000.0104, decision No 352.934).

Forty-eight sound human third molars, with similar dimensions (11.5 mm long and 10 mm in diameter), freshly extracted for therapeutic reasons, were used in this study. All teeth were formally donated by patients to the tooth bank at UEM for future research with the signature of an informed donor. Examination under a light microscope (×10) revealed no cracks, caries, or discoloration. All teeth were hand-brushed with soap and water, followed by scaling with a 13/14 Columbia University periodontal curette (Hu-Friedy Mfg Co) to remove any adhering materials, and then stored in saline solution. Each tooth was then embedded in a base of pink autopolymerizing acrylic resin (JET; Artigos Odontológicos Clássico) measuring 1×1×4 cm, 4 mm below the cemento-enamel junction.

After polymerization, the specimens were individually fixed to a vice and prepared for complete ceramic crowns with conventional diamond rotary instruments fixed to a high-speed (380 000 rpm) handpiece (EXTRAtorque 605C; KaVo do Brasil Ind Com Ltd). First, the occlusal surface was reduced with a #4103 diamond rotary instrument (KG Sorensen). Complete crown preparation was then conducted with a #3216 (round) followed by a #4138 (tapered) diamond rotary instrument (KG Sorensen). A new set of instruments was used for the preparation of each tooth, which was conducted by the same operator (T.F.S.), aiming for a 6-degree taper. The margins were prepared to a rounded shoulder configuration above the cemento-enamel junction, as described by Shillingburg et al.[18] When all teeth had been prepared, they were randomly allocated (by drawing lots) to the 4 experimental groups (n=12). The margins were then refined with 1 of the 4 experimental finishing instruments (Fig. 1), according to their respective groups:

- HT: Cervical margin finishing was conducted with a hand trimmer with a sharp point and round angle (MA2 Safident; Cosmedent). The trimmer was used in horizontal, forward and backward movements by applying slight pressure against the wall of the tooth. To standardize the procedure, the trimmer was hand-sharpened after each tooth preparation with an Arkansas stone (SS4; Hu-Friedy Mfg Co).
- TCB: The cervical margin was finished with a round #283 tungsten carbide bur (Jet carbide dental burs, Kerr) mounted in a reduced speed (180 000 rpm) contra angle handpiece (Koncept 1:5; KaVo do Brasil Ind Com Ltd). The bur was positioned perpendicularly to the tooth, and horizontal continuous movements were performed along the margin.
- DRI: Finishing was conducted with the same #4138 diamond rotary instrument (KG Sorensen) previously used for tooth preparation and mounted in the same contra angle handpiece used in TCB. The diamond rotary instrument was positioned perpendicularly to the tooth in movements identical to those used for tooth preparation.
- UI: The cervical margin was finished with a CR4 ultrasonic instrument (CVDentus 1000; Clorovale Diamantes Indústria e Comércio Ltda) with the power set at 80%, as recommended by the manufacturer. Simultaneous apical and horizontal

Figure 1. Instruments used for finishing procedures. A, Hand trimmer (HT group). B, Tungsten carbide bur (TCB group). C, Diamond rotary instrument (DRI group). D, Ultrasonic instrument (UI group).

movements under irrigation were performed by applying light pressure. According to the manufacturer, the ultrasonic CVD diamond tip is long-lasting and can be effectively used for up to 300 procedures. Thus, the same diamond tip was used for all finishing procedures in the group.

Cervical margin finishing time was limited to 2.5 minutes for all instruments, and all procedures were performed by the same operator (T.F.S.), who was previously trained for each individual instrument. All specimens were numbered and submitted to scanning electron microscopy (Microscope Superscan SSX-550 SEM-EDX; Shimadzu Corp) before and after the finishing procedure without being sputter coated with gold (×40 magnification). Images showing the unfinished and the finished cervical margin profiles (Fig. 2) were numbered 1 to 96. Two sets of 96 images randomly organized in 2 different orders (drawing lots) were prepared in presentation software (PowerPoint 2010; Microsoft Corp).

Nine dental professionals (prosthodontists, restorative dentists, and prosthetic technicians) were invited, based on their experience in the area (>10 years), to qualitatively assess their perception of the ELA. Each set of images were sent by email within a 15-day interval to the evaluators, who were blinded to the procedures. They were instructed to rate the images according to the following scores: 1, poor (would definitely result in an ill-fitting restoration); 2, fair (would probably result in an ill-fitting restoration); 3, good (would probably result in a well-fitting restoration; 4, very good (would definitely result in a well-fitting restoration). Analysis should be conducted in a dark environment, and focus should be placed on the regularity of the ELA. Each evaluator rated each image twice, totalling 192 viewings.

The Cohen kappa nonparametric test was used to measure the level of agreement between assessments of the same images. The average scores among the 9 raters were used as the outcomes, and paired *t* tests between unfinished and finished scores were performed for each procedure to determine whether a significant change occurred. Post hoc power analysis for the paired *t* test based on the size of the sample for each instrument was also conducted. Repeated measures ANOVA with "unfinished" and "finished" being levels of a within subjects factor and "procedure" being a between subjects factor was performed to compare the 4 procedures

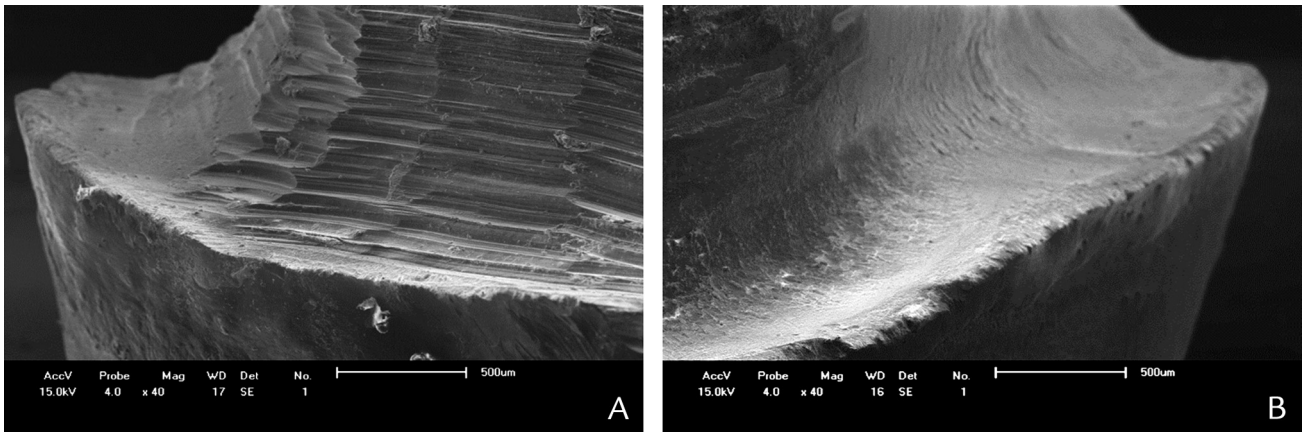

Figure 2. Scanning electron microscope images (×40). A, Unfinished tungsten carbide bur (TCB) specimen. B, Finished TCB specimen.

statistically, followed by the Tukey HSD test of all pairwise differences. All statistical analyses were conducted with statistical software (R Core Team, 2015; R Foundation for Statistical Computing).

RESULTS

The Cohen kappa nonparametric test demonstrated that the level of agreement between the 2 assessments was moderate (Table 1). Figure 3 displays the average scores attributed by raters to the ELAs of each tooth in the group before and after the finishing procedures.

The *P* values from paired *t* test and their respective power are listed in Table 2. DRI was the only group to demonstrate significant ELA improvement ($P<.001$). In percentage terms, while DRI, TCB, and UI demonstrated some improvement, HT presented a reduced ELA. Moreover, of the 12 teeth in the group, DRI presented 11 teeth with improved ELAs, UI had 8, and TCB and HT had 7 (Table 2).

The repeated measures ANOVA demonstrated statistically significant differences among procedures ($F_{(3,187)}=28.87$, $P<.001$). The Tukey multiple comparisons test demonstrated that, except for HT in relation to TCB, all the other pairwise differences were statistically significant ($P<.05$) (Table 3).

DISCUSSION

The effectiveness of 4 different instruments used for cervical margin finishing were assessed with regard to the ELA. It was initially hypothesized that the ELA would not be significantly improved by any of the finishing instruments tested. However, the results of this study demonstrated that the diamond rotary instrument was capable of significantly improving the ELA, supporting the rejection of the null hypothesis.

Sufficient professional knowledge and the perfect control of instruments are fundamental preconditions for achieving an excellent tooth preparation for prosthetic restorations.[7] Previous authors have identified 3 different areas of attention: the axial wall/marginal angle; the margin surface; and the ELA.[8] The information arising from the literature seems to suggest that no one instrument is capable of effectively improving all 3 areas.[8] While some instruments may improve one particular area of the margin, others may be more effective in others. The data obtained in this study seem to corroborate this perception.

Teeth in the DRI group were submitted to cervical margin finishing with the same round, tapered-body #4138 diamond rotary instrument used in tooth preparations. For finishing purposes, however, the instrument was mounted in a contra angle handpiece with reduced speed. This change seems to have conferred more operator control during the finishing procedures. As a result, the ELA of 11 of the 12 teeth in this group were judged to have been improved after the finishing procedure. This represented an overall improvement of 33.33%. This result is in agreement with the findings of a previous study that demonstrated that diamond rotary instruments produced a sharp, continuous, well-defined ELA, which the authors considered to be ideal.[8]

Although scores improved for 8 of 12 teeth in the UI group after the finishing procedures, finished ELA results were not significantly higher when compared with

Table 1. Kappa agreement results for procedures tested

Instrument	Value	95% Confidence Limits		Agreement
HT unfinished	0.5987	0.4767	0.7207	Moderate
HT finished	0.4413	0.3066	0.5760	Moderate
TCB unfinished	0.4386	0.3005	0.5766	Moderate
TCB finished	0.4375	0.3045	0.55705	Moderate
DRI unfinished	0.4134	0.2800	0.5468	Moderate
DRI finished	0.4884	0.3626	0.6142	Moderate
UI unfinished	0.4552	0.3264	0.5840	Moderate
UI finished	0.5031	0.3733	0.6329	Moderate

HT, hand trimmer; TCB, tungsten carbide bur; DRI, diamond rotary instrument; UI, ultrasonic instrument.

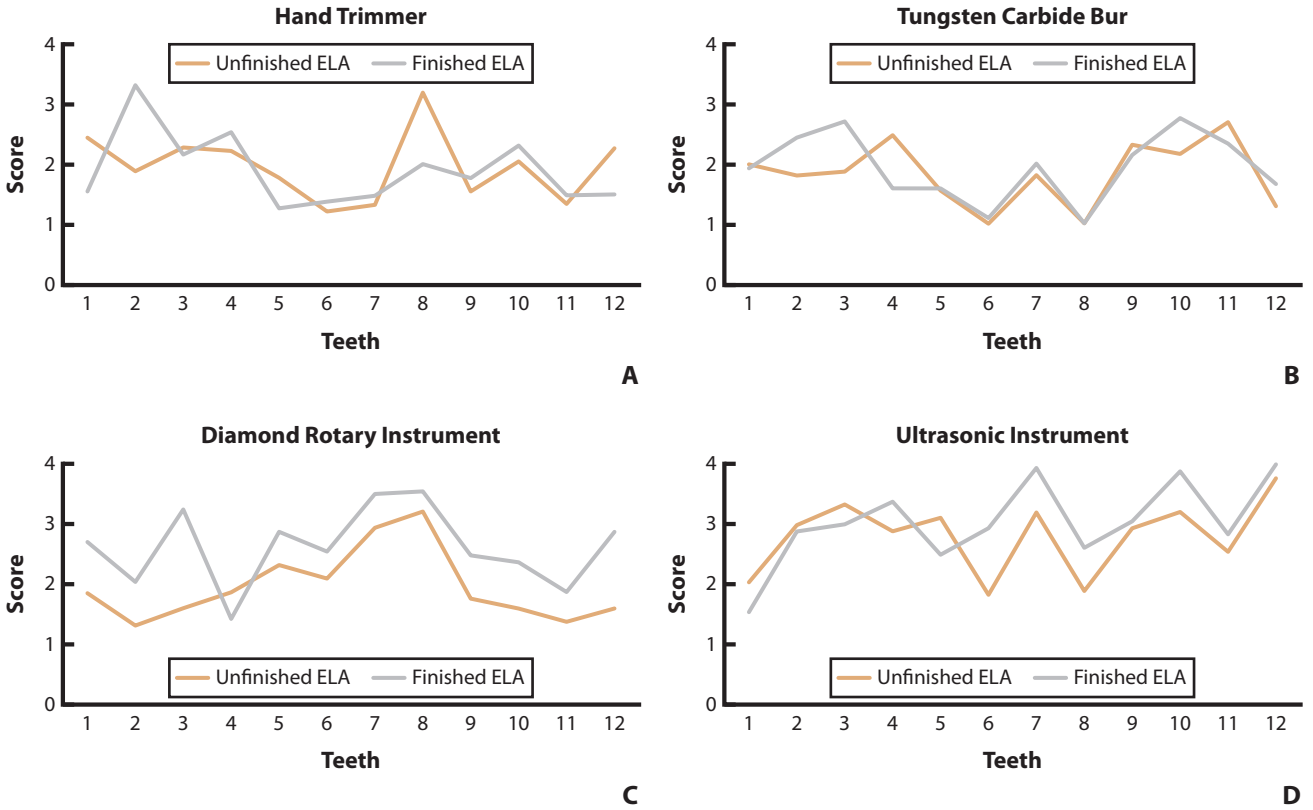

Figure 3. Graphs showing mean scores attributed by examiners to teeth. A. Hand trimmer (HT) group before and after cervical margin finishing. B, Tungsten carbide bur (TCB) group before and after cervical margin finishing. C, Diamond rotary instrument (DB) group before and after cervical margin finishing. D, Ultrasound bur (USB) group before and after cervical margin finishing.

Table 2. Mean qualitative scores attributed by examiners to external line angles of cervical margins

Finishing Instrument	Mean ELA scores					ELA		
	Unfinished	Finished	*P*	Power	ELA Change	Improved	No Change	Worsened
HT	1.9675	1.9074	.682	.375	-3.04%	7	–	5
TCB	1.8472	1.9490	.318	.318	5.40%	7	1	4
DRI	1.9768	2.6388	<.001	.999	33.33%	11	–	1
UI	2.8194	3.0509	.051	.692	8.15%	8	–	4

ELA, external line angle; HT, hand trimmer; TCB, tungsten carbide bur; DRI, diamond rotary instrument; UI, ultrasonic instrument.

unfinished results. The lack of statistically significant differences between unfinished and finished scores indicates that the ultrasonic instrument used had little effect on the ELA. However, a discrepancy was observed in the UI group. The unfinished ELA scores for the teeth in this group were markedly higher than in the other 3 groups. Considering that all teeth were prepared under the same conditions and were randomly allocated to their groups by drawing lots before any finishing procedures were conducted, this difference was probably determined by chance. A considerable number of unfinished preparations obtained high scores (3 and 4). It seems that more unfinished teeth with higher scores coincidently fell in the UI group. The fact that the slightly higher finished values found for ELA in the UI group were in line with the findings in other groups in the study indicates that the preparations were adequately scored.

Table 3. Tukey multiple comparisons of mean results

Comparison	*P*
HT-TCB	.989
HT-DRI	.017
HT-UI	<.001
TCB-DRI	.006
TCB-UI	<.001
DB-UI	<.001

HT, hand trimmer; TCB, tungsten carbide bur; DRI, diamond rotary instrument; UI, ultrasonic instrument.

Different from rotary instruments, ultrasonic instruments have an oscillating action, which have

recently been adapted for finish line preparation in fixed prosthodontics.[6] The main advantage of ultrasonic instruments is that they are largely atraumatic to the gingival attachment, pulp, and adjacent teeth.[6] In a recent study, the use of ultrasonic instruments produced preparation margins that were smooth, with a well-defined and rounded axial wall/margin angle. However, the oscillating action of the instrument was considered responsible for causing pieces of enamel to fracture, resulting in a chipped ELA.[8] Although the data for this modality suggest that improved familiarity and operator skill may lead to better results,[6] this is still uncertain.

In the HT group, the hand instrument tested was not capable of significantly improving ELA. In fact, although 7 of the 12 teeth in the group received better scores after the finishing procedures, a reduction in the mean ELA score was observed, indicating that hand finishing appears to be detrimental to the quality of the ELA. Moreover, in a previous study, hand planing was found not to reduce the roughness of the axial wall, another important characteristic in shoulder preparation.[12] Thus, the results seem to suggest that hand finishing is not a worthwhile procedure.

Similarly, in the TCB group, no significant differences were found between unfinished and finished specimens. While tungsten carbide burs have been shown to be effective in regularizing the axial wall of cervical margin preparations,[1] they also frequently damage the marginal finish line. The reason may be the design of the instrument. The multilaminated tip of the bur caused scratches on the margin surface and chipping of the finish line during the adaptation to the shape of the margin initially created by the diamond rotary instrument during preparation (Fig. 2B). Hence, the poor results found here suggest that tungsten carbide burs may not be the most suitable instrument for improving the ELA.

The qualitative assessment of margin preparations is a highly subjective exercise. However, this is exactly what clinicians do in their daily practice. They depend on their knowledge and experience to determine whether a particular preparation will result in an adequately fitting restoration. In order to achieve some degree of objectivity, a group of 9 experienced dental professionals were invited to assess the quality of preparations both before and after the finishing procedures. By having a pool of expert opinions, the effectiveness of a particular finishing instrument was expected to be judged more consistently. Nonetheless, questions may arise regarding the criteria and the assessment strategy used in this study.

Most importantly, whether examiners can or cannot predict the ill-fitting or well-fitting of a restoration based on an image is a matter of debate. By using SEM photomicrographs, examiners should be able to capture more subtle differences in finish line preparation and, therefore, produce more objective predictions of the final fitting of the restoration. The raters were only given instructions on the focus of their observations and on the scores to be given, and decisions were made based on experience. Thus, no training or calibration was conducted–an important limitation that might have affected the scoring process. The moderate agreement between viewings suggests that raters were sometimes uncertain about the scoring of a particular preparation (Table 1). While the difference between score 1 (poor) and 4 (very good) should be quite straightforward, the choice between 2 consecutive scores was probably fuzzy, somewhat accounting for the differences between the first and second assessment. Nonetheless, based on the number, experience, and diversity of examiners who participated in this study, a good correlation between the subjective qualitative evaluation of the finish line and the fit of the restoration may be assumed. A further study, in which crowns would be built for each tooth, would be necessary to verify whether such an association exists.

CONCLUSIONS

Within the limitations of the present study, the diamond rotary instrument mounted in a contra angle handpiece was the only finishing instrument capable of significantly improving the ELA. The tungsten carbide bur and the ultrasonic instrument produced nonsignificant improvement, while the hand trimmer was detrimental to ELA.

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Corresponding author:
Dr Lilian Cristina Vessoni Iwaki
State University of Maringá (UEM)
Avenida Mandacaru nº 1550, bloco S-08
87080-000, Maringá – PR
BRAZIL
Email: lilianiwaki@gmail.com

Acknowledgments
The authors thank Mr Antonio Carlos Correa for his support with the English version of the paper.

Noteworthy Abstracts of the Current Literature

Time-efficiency analysis comparing digital and conventional workflows for implant crowns: A prospective clinical crossover trial

Joda T, Brägger U

Int J Oral Maxillofac Implants 2015;30:1047-53

Purpose. To compare time-efficiency in the production of implant crowns using a digital workflow versus the conventional pathway.

Materials And Methods. This prospective clinical study used a crossover design that included 20 study participants receiving single-tooth replacements in posterior sites. Each patient received a customized titanium abutment plus a computer-aided design and computer-assisted manufacture (CAD-CAM) zirconia suprastructure (for those in the test group, using digital workflow) and a standardized titanium abutment plus a porcelain-fused-to-metal crown (for those in the control group, using a conventional pathway). The start of the implant prosthetic treatment was established as the baseline. Time-efficiency analysis was defined as the primary outcome, and was measured for every single clinical and laboratory work step in minutes. Statistical analysis was calculated with the Wilcoxon rank sum test.

Results. All crowns could be provided within two clinical appointments, independent of the manufacturing process. The mean total production time, as the sum of clinical plus laboratory work steps, was significantly different. The mean ± standard deviation (SD) time was 185.4 ± 17.9 minutes for the digital workflow process and 223.0 ± 26.2 minutes for the conventional pathway (P = .0001). Therefore, digital processing for overall treatment was 16% faster. Detailed analysis for the clinical treatment revealed a significantly reduced mean ± SD chair time of 27.3 ± 3.4 minutes for the test group compared with 33.2 ± 4.9 minutes for the control group (P = .0001). Similar results were found for the mean laboratory work time, with a significant decrease of 158.1 ± 17.2 minutes for the test group vs 189.8 ± 25.3 minutes for the control group (P = .0001).

Conclusion. Only a few studies have investigated efficiency parameters of digital workflows compared with conventional pathways in implant dental medicine. This investigation shows that the digital workflow seems to be more time-efficient than the established conventional production pathway for fixed implant-supported crowns. Both clinical chair time and laboratory manufacturing steps could be effectively shortened with the digital process of intraoral scanning plus CAD-CAM technology.