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The influence of different drives and diamond rotary instruments on the design of the surfaces following dental preparations — an experimental study

KEYWORDS: Dental preparation, drives, diamond rotary instruments, waviness

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ABSTRACT *Dental preparations require a high degree of precision. The goal of the study was to examine the surface design from the use of different drives.*

The study was conducted under standardized, clinically simulated conditions. The test subjects prepared surfaces on CEREC VITABLOCS MARK II using three drives that facilitated and did not facilitate contact grinding. In addition, various diamond rotary instruments were used. The waviness parameter Wt (wave depth) showed significantly smaller values for the drives that enabled contact grinding than for the older turbines that did not. No significant differences were found in the comparison of the results for the GENTLEforce 7000 B turbine and the micromotor with speed-enhanced contra-angle piece. The parameter RSm (groove width) showed the highest values for the older turbines.

As relatively large convergence angles are achieved in the dental preparations with patients, the significant differences in waviness on the surfaces have little clinical importance.

INTRODUCTION

Numerous publications are dedicated to a wide variety of aspects of dental preparation, with the primary focus being on the shaping of the tooth to be prepared [1 - 8]. Other aspects included the abrasion rates and cutting performance of the diamond and carbide rotary instruments [9 - 11]. Likewise, the roughness and the design of the prepared tooth surfaces were tested in conjunction with the fixation material [12, 13]. Other studies looked at the effect of temperature on the pulp during preparation [14-16].The quality of dental preparation, particularly in the area of the finish line, influences the treatment outcome for permanent restorations [6, 7, 17]. Not only the dexterity and experience of the dentist are important [18]; the dental manufacturers with their drives, grinders and rotary instruments and their ongoing development influence the preparation results as well [15,19]. During the preparation, hard tissue is removed at high speed. For this purpose, primarily two types of drives are used - micromotors with high-speed contra-angle handpieces and air turbines [20, 21]. Less frequent use of micromotors compared to turbines was noted in the United States [19]. Turbines are operated with compressed air and the speed is up to 450,000 rpm. With a classical turbine, the speed drops drastically upon contact with the tooth [22]. The speed cannot be controlled in the turbines. In contrast, micromotors are electrically driven, and the speed is selectable. The speed of the rotary instrument is additionally influenced by the transmission ratio of the attached high-speed contra-angle handpiece. For example, the effective speed achievable ranges up to 200,000 rpm. The electronic speed stabilization ensures that the selected speed is maintained even under load, i.e. during contact of the rotary instrument with the tooth [21]. More recently, turbines that likewise maintain their speed during the preparation of dental hard tissue have been developed. Each grinding process produces complex surfaces with form defects that can be characterized using surface parameters.

The primary goal of the study was to compare the results of surfaces after dental preparation under simulated clinical conditions. The focus was on the influence of various drives and diamond rotary instruments in accordance with the selected topic, the waviness parameters of the prepared surfaces.

The working hypotheses are as follows:

- For turbines with and without the option of contact grinding, the waviness parameters of the prepared surfaces would vary.
- When micromotors were used, waviness parameters of the prepared surfaces would correspond to those of the newer type of turbines (with contact grinding).
- When micromotors were used, the waviness parameters would differ from those arising from the use of the older type of turbine.
- The additionally tested influence of different types of diamond rotary instruments would only differ in the effect of medium grit and fine grit forms on the preparation surfaces.

MATERIALS and METHODS

Test subjects

The trials were conducted under conditions adequate for practice. Ten test subjects were included. All of them were clinically experienced female dental students. They were familiar with the function and handling of the dental drives and diamond rotary instruments from studies. The selection of only female test subjects was intentional, as women are increasingly pursuing careers in

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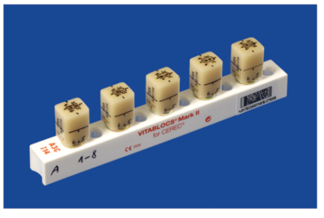
dentistry. This also contributed to the homogenization of the study conditions. In the selection of the test subjects, care was taken to ensure comparability of age, height and weight and health status. The medians were 23 years, 168 cm and 57 kg. All test subjects were right-handed. None of the test subjects mentioned current physical problems or medical treatments in their medical histories.

Specimens
The specimens used were commercially available CEREC VITABLOCS MARK II blanks (Vita), as used for the fabrication of inlays and crowns (Figure 1). The material

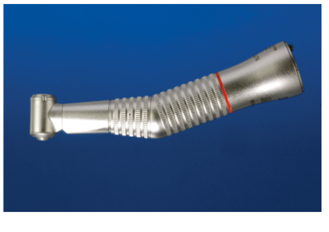
Figure 1 Specimens used for the study. The markings for the specified preparations can be seen on the Vitablocs Mark II.



is feldspat ceramic. The manufacturer characterizes theses products as follows: homogeneous structure, abrasion resistance resembling that of the human dental enamel, pressure resistance 757 MPa, flexural strength 154 MPa and modulus of elasticity 63 GPa. The dimensions were 14 x 12 x 8 mm (width x depth x height). A deliberate decision was made not to use any extracted natural teeth to prevent individual differences in the dental hard tissue from influencing the results.

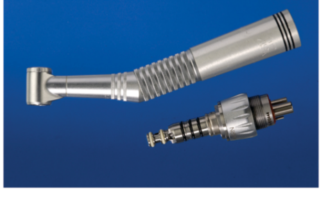
Drives
All of the drives were commercially available, new and unused. The following instruments were compared in the study (all KaVo):
- a micromotor with a high-speed contra-angle handpiece (Figure 2) of the INTRA LUX 3 type (step-up ratio 1:5), of the 25 LHS type (three spray jet system and ceramic ball bearings); the electric micromotor had an INTRAmatic LUX coupler with an internal light source; its maximum speed was 40,000 rpm.

Figure 2 INTRA-LUX 3 speed-enhanced contra-angle handpiece



- an older, commercially available air-driven turbine of the Super All Air 631 type with the matching 465 RN coupler (Figure 3)

Figure 3 Super All Air 631 turbine with the corresponding 465 RN coupler

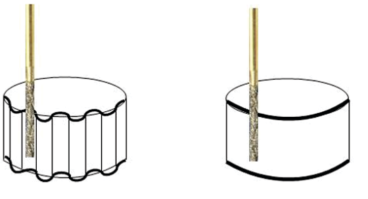


- a newer air-driven turbine of the GENTLEforce 7000 B type with the corresponding MULTIflex LUX coupler (Figure 4).

Figure 4 GENTLEforce 7000 B turbine with the corresponding MULTIflex LUX coupler

According to the manufacturer's specifications, "contact grinding" is possible with both the INTRA LUX 3 speed-enhanced contra-angle handpiece coupled to the micromotor and with the GENTLEforce 7000 B. That means that constant contact between the grinding tool and the tooth/specimen with a contact pressure of up to 2 N is possible during the grinding [23]. This is an expression of the high torque of the drive. In contrast to this, with older turbines such as the Super All Air 631 turbine, only discontinuous "spot grinding" is possible due to the drop in speed when the diamond rotary instrument is in contact with the tooth/specimen. This is an expression of the low torque of the drive. This results in different preparation surfaces (Figure 5). Care was taken to ensure that the air pressure recommended by the

Figure 5 Schematic drawing of the effects on the preparation surface; on the left the spot contact (idealized – the grooves are not parallel in the preparation and are not equally deep) and on the right the situation idealized following contact grinding is shown



manufacturer for the turbines was available. For the Super All Air 631 turbine, the necessary forced air pressure was set to 3.5 bar with the aid of a multiflex manometer on the dental treatment unit. In contrast, the GENTLEforce 7000 B turbine had an internal pressure control, which automatically reduced the feed pressure to 2.8 bar.

Diamond rotary instruments
Commercially available and new diamond rotary instruments commonly used in practice were used for the study (Figure 6 and Table 1). All diamond rotary

Figure 6 The six types of diamond rotary instruments used (from left to right): Cool - diamond rotary instrument, torpedo form, medium grit (A) / Cool – diamond rotary instrument, cylinder, medium grit (B) / Diamond rotary instrument without cooling grooves, torpedo, medium grit (C) / Diamond rotary instrument without cooling grooves, torpedo, fine grit (D) / Diamond rotary instrument without cooling grooves, cylinder, medium grit (E) / Diamond rotary instrument without cooling grooves, cylinder, fine grit (F)

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Table 1 Survey of the types of diamond rotary instruments used (manufacturers' data); # - ISO – number not available

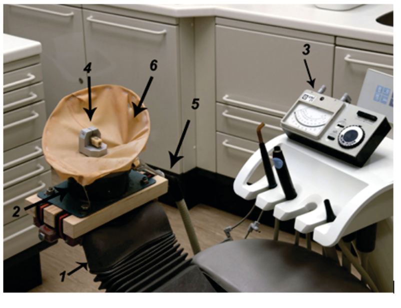
Type of diamond rotary instrument	Basic design	Roughness	Grit size [µm]	Designation /ISO – number:	Abbreviation used in tables 2 to 5
Cool – diamond rotary instrument	torpedo	medium	90 - 125	CD 69 014 /#	A
	cylinder with rounded edge			CD 25 014 /#	B
Diamond rotary instrument without cooling grooves	torpedo	medium	90 - 125	878 014 /ISO: 806 314 289 524014	C
		fine	30 - 50	8878 014 / ISO:806 314 289 514 014	D
	cylinder with rounded edge	medium	90 - 125	837 KR 014 / ISO: 806 314 158 524 014	E
		fine	30 - 50	8837 KR 014 / ISO: 806 314 158 514 014	F

instruments had a working part length of 8 mm, a working part diameter of 1.4 mm and a total length of 22 mm [21, 23]. All diamond rotary instruments were produced by Busch.

Test design

All tests were conducted in a separate operatory on a dental treatment unit of the Sirona C 2 type (Sirona Dental). For the specimens, the height-adjustable, swiveling dentist's stool (type: Physioform; Sirona Dental) was individually adjusted. The VITA-MARK II ceramic blocks to be ground were fixed in place using a two-part holder on the force measuring device (KG 1; TU Dresden), which in turn was fastened to the headrest of the patient's chair (Fig. 7). The UNI 21 display unit (Mellenbacher

Figure 7 Test workstation; 1 – Head section of the patient's chair; 2 – Force sensor of the force measuring device ; 3 UNI 21 display device; 4 – Specimen with holder; 5 – Spray mist suction; 6 – Rubber dam



Messtechnik), on which the initiated contact pressure could be monitored during the preparation via a force sensor, was always in the field of view of the specimens. The force sensor was protected from moisture by a rubber dam mounted below the specimen holder; the spray mist suction was attached to the rubber dam at the latter's lowest point.

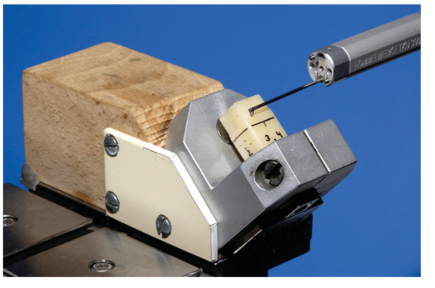
Testing

The study was conducted under standardized conditions. It began for all test subjects at 7:30 a.m., so that physical stress due to other activities was absent. The test subjects were also asked to be well-rested when they came to the test [24]. Everyone participated in the study voluntarily. Before the start of the study, all test subjects were uniformly informed about the test procedure. They were monitored to ensure an ergonomic sitting posture [25]. The simulation of clinical conditions was supplemented with good lighting, the use of spray mist at a rate of 50 ml water/minute [26, 27], spray mist suction and the use of protective gloves and glasses. The order in which the micromotor, older turbine and newer turbine as well as the various diamond rotary instruments were used was specified in advance. A permuted test design was implemented. After an initial opportunity to practice with all drives, the actual test run began. Contact grinding was accomplished with the micromotor and the GENTLEforce 7000 B turbine, while all test subjects used the spot grinding technique with the older turbine. The thickness of the layer to be removed was less than 1 mm for the diamond rotary instruments with medium grit. The test subjects were requested to design the finish line as straight as possible. The specimens were marked for orientation purposes in this regard (Figure 1). All test subjects prepared 8 specimens each per drive with each of the three drives. The test subjects were required to use the full 8 mm working part length of the diamond rotary instruments. New diamond rotary instruments were used for each test section. The grinding time for the medium grit diamond rotary instruments was limited to 1 minute per individual surface and to 30 seconds for the use of the fine grit diamond rotary instruments. The principal investigator monitored compliance with all of the aforementioned times using a stopwatch. After each test section, a planned break of 10 minutes was taken to rest the test subjects' muscles. Before each test section began, the principal investigator checked to ensure that the compressed air supply specified by the manufacturer was available and that the speed of the micromotor was preselected at 40,000 rpm. During the tests there was assurance that the contact pressure of the bur on the specimen was maintained at 2 N. All of these measures served to homogenize the conditions under which the tests were conducted.

Data analysis and statistics

Assessment of the preparation surfaces was conducted via tactile scanning of the surface sections. The Hommel tester T 6000 surface measuring unit (Hommel) was used for this purpose. Thanks to the use of the very gracile TKU 300 scanner, it was also possible to measure the waviness of the finish line. Three areas were selected for analysis: the finish line (FL) (chamfer and shoulder) (Figure 8) and the smooth

Figure 8 Specimen fixation for measurement on the Hommel tester



surfaces near to the finish line (NFL) as well as an area away from the finish line (DFL). The last two areas of analysis corresponded to the lines that separate the prepared surface into thirds. The measuring distance was 1.5 mm in each case. The threshold wavelength λc – the cut-off filter – required for the analysis was specified at 0.25 mm in accordance with ISO 4288 [28]. In accordance with the selected focal points of the study, the total height of the waviness profile (Wt) and the mean width of the waviness profile elements (RSm) were analyzed - ISO 4287 [29]. The Mann-Whitney U tests were used for the statistical comparisons. To counteract the problem of multiple testing, the Bonferroni adjustment was used with paired comparisons (α = .050).

RESULTS

Drives

The medians for the waviness parameter Wt of the three drives are compared in Table 2. The highest Wt values were measured for drive 2 - the older turbine -, for

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Table 2 Medians of the parameter wave depth (WT) for the measuring points FL (finish line), NFL (near to finish line smooth area) and DFL (distant to finish line smooth area) for all types of drives and diamond rotary instruments [µm];

Drives: 1 – micromotor with speed-enhancing contra-angle piece; 2 – Turbine Super – All – air 631; 3 – Turbine GENTLEforce 7000 B Diamond rotary instruments: A – COOL – diamond rotary instruments, torpedo, medium roughness; B – COOL – diamond rotary instruments, cylinder, medium roughness; C – diamond rotary instruments without cooling grooves, torpedo, medium roughness; D – diamond rotary instruments without cooling grooves, torpedo, fine roughness; E – diamond rotary instruments without cooling grooves, cylinder, medium roughness; F – diamond rotary instruments without cooling grooves, cylinder, fine roughness.

MEASURING POINTS/DIAMOND ROTARY INSTRUMENTS																			
		FL/A	FL/B	FL/C	FL/D	FL/E	FL/F	NFL/A	NFL/B	NFL/C	NFL/D	NFL/E	NFL/F	DFL/A	DFL/B	DFL/C	DFL/D	DFL/E	DFL/F
DRIVES	1	22.9	16.1	16.7	16.1	15.8	10.6	21.4	23.1	16.5	15.7	20.2	11.7	19.0	22.1	15.8	13.8	18.5	12.4
	2	28.9	24.4	25.9	17.6	25.8	13.4	28.8	26.7	24.7	15.9	22.0	16.9	27.8	25.3	22.0	14.2	24.2	18.3
	3	19.1	15.1	15.0	13.2	13.3	9.8	17.3	17.0	14.2	10.8	14.9	11.0	16.2	17.8	13.5	10.9	13.8	11.6

each type of diamond rotary instrument and at every measuring point. After the specimens had been processed with the newer turbine (drive 3) and the data were compared with those of the micromotor (drive 1), the lowest Wt medians for all types of diamond rotary instrument and measuring points were found for the newer turbine. In the statistical tests of the finish line results, the difference between the older turbine and the micromotor and between the older turbine and the new turbine were statistically confirmed (Table 3 / FL). No statistically confirmed difference between the

Table 3 Statistical comparison of the results of the drives for the wave depth (Wt) as a function of the types of diamond rotary instruments used for the three measuring points: FL – finish line: NFL – near to finish line smooth surface; DFL – distant to finish line smooth surface;

Drives: 1 – micromotor with speed-enhancing contra-angle piece); 2 – Turbine Super-All-air 631; 3 – Turbine GENTLEforce 7000 B; Diamond rotary instruments: A – COOL- diamond rotary instruments, torpedo, medium roughness; B – COOL – diamond rotary instruments, cylinder, medium roughness; C – diamond rotary instruments without cooling grooves, torpedo, medium roughness; D – diamond rotary instruments without cooling grooves, torpedo, fine roughness; E – diamond rotary instruments without cooling grooves, cylinder, medium roughness; F – diamond rotary instruments without cooling grooves, cylinder, fine roughness; U – Test according to Mann / Whitney with Bonferroni - adjustment; s. - significant

	Measuring points / Diamond rotary instruments						
	FL	**FL / A**	**FL / B**	**FL / C**	**FL / D**	**FL / E**	**FL / F**
Comparison of drives	**1 – 2**	<.001 s.	<.001 s.	<.001 s.	.138	<.001 s.	.040 s.
	1 – 3	.271	.647	.348	.157	.118	.105
	2 – 3	<.001 s.	<.001 s.	<.001 s.	<.001 s.	<.001 s.	<.001 s.
	NFL	**NFL / A**	**NFL / B**	**NFL / C**	**NFL / D**	**NFL / E**	**NFL / F**
	1 – 2	<.001 s.	.008 s.	<.001 s.	1.000	.265	.001 s.
	1 – 3	.043 s.	<.001 s.	.139	.004 s.	.001 s.	1.000
	2 - 3	<.001 s.	<.001 s.	<.001 s.	.001 s.	<.001 s.	<.001 s.
	DFL	**DFL / A**	**DFL / B**	**DFL / C**	**DFL / D**	**DFL / E**	**DFL / F**
	1 – 2	<.001 s.	.013 s.	<.001 s.	1.000	.004 s.	.017 s.
	1 – 3	.209	.009 s.	.029 s.	.020 s.	<.001 s.	.182
	2 – 3	<.001 s.	<.001 s.	<.001 s.	.008 s.	<.001 s.	<.001 s.

results achieved with the micromotor and the newer turbine were found for the clinically important area of the finish line. If one reviews the analyzed areas of the smooth surfaces near to and distant from the finish line, statistically significant differences among all three drives are found throughout (Tables 3 / NFL and DFL). With regard to the diamond rotary instruments, no significant differences occurred, particularly after use of the fine grit diamond rotary instruments (Table 3 / FL, NFL and DFL). The second parameter analyzed was the mean width of the waviness profile elements (RSm). The medians for these parameters are listed in Table 4.

Table 4 Medians of the parameter medium groove depth (RSm) for the measuring points FL (finish line), NFL (near to finish line smooth surface) and DFL (distant to finish line smooth surface) for all types of drives and diamond rotary instruments [µm]; The abbreviations of the drives and diamond rotary instruments correspond to those in table 2.

MEASURING POINTS/DIAMOND ROTARY INSTRUMENTS																			
		FL/A	FL/B	FL/C	FL/D	FL/E	FL/F	NFL/A	NFL/B	NFL/C	NFL/D	NFL/E	NFL/F	DFL/A	DFL/B	DFL/C	DFL/D	DFL/E	DFL/F
DRIVES	1	84	67	76	57	63	44	80	83	78	53	79	53	80	81	76	54	76	52
	2	103	82	97	63	79	44	92	94	86	58	92	56	91	89	87	54	89	52
	3	75	60	66	51	58	32	75	78	73	51	72	47	72	72	67	51	71	46

Once again, the medians for the RSm values were the highest after the use of the older turbine, even taking all the diamond rotary instruments and analyzed regions into account. After the specimens had been processed with the newer turbine and the data were compared with those of the micromotor, the lowest RSm medians for all types of diamond rotary instruments and measuring points were found for the newer turbine. It is striking that the differences in the RSm values after specimen processing with the newer turbine compared to the micromotor were smaller than the differences between the micromotor and the older turbine. In the statistical testing of the results for all three measuring points, statistical differences were confirmed in almost all cases (Table 5 / FL, NFL and DFL). With regard to the diamond rotary

Table 5 Statistical comparison of the results of the drives at a medium groove depth (RSm) as a function of the types of diamond rotary instruments used at the three measuring points:

FL – finish line; NFL – near to finish line smooth surface; DFL – distant from finish line smooth surface; The abbreviations for the types of drives and diamond rotary instruments used correspond to those in table 3. U – Test according to Mann / Whitney with Bonferroni adjustment; s. - significant

	Measuring points / Diamond rotary instruments						
	FL	**FL / A**	**FL / B**	**FL / C**	**FL / D**	**FL / E**	**FL / F**
Comparison of drives	**1 – 2**	<.001 s.	<.001 s.	<.001 s.	.002 s.	<.001 s.	1.000
	1 – 3	.002 s.	.174	<.001 s.	.023 s.	.216	<.001 s.
	2 – 3	<.001 s.	<.001 s.	<.001 s.	<.001 s.	<.001 s.	<.001 s.
	NFL	**NFL / A**	**NFL / B**	**NFL / C**	**NFL / D**	**NFL / E**	**NFL / F**
	1 – 2	<.001 s.	<.001 s.	.002 s.	.176	<.001 s.	.732
	1 – 3	.021 s.	<.030 s.	.022 s.	.283	<.007 s.	<.001 s.
	2 - 3	<.001 s.	<.001 s.	<.001 s.	.002 s.	<.001 s.	<.001 s.
	DFL	**DFL / A**	**DFL / B**	**DFL / C**	**DFL / D**	**DFL / E**	**DFL / F**
	1 – 2	<.001 s.	.002 s.	.002 s.	.664	<.001 s.	1.000
	1 – 3	<.001 s.	<.001 s.	.001 s.	.311	.005 s.	.001 s.
	2 - 3	<.001 s.	<.001 s.	<.001 s.	.028 s.	<.001 s.	<.001 s.

instruments, differences that could not be confirmed appeared almost exclusively after use of the fine grit diamond rotary instruments (Table 5 / FL, NFL and DFL).

Diamond rotary instruments

When we look at the diamond rotary instruments taking all three measuring points into account, the COOL diamond rotary instruments always achieved the highest values for the Wt and RSm parameters. For the total height of the waviness profile Wt, the average values when the medium grit was used, compared to the COOL diamond rotary instruments, were 12 to 27% lower. The results of the fine grit diamond rotary instruments were 37 to 39%. The average values were more homogenous for the RSm parameter. The difference between the results of the medium grit and the COOL diamond rotary instruments was only 4 to 7%, while the average values taking the fine grit diamond rotary instruments into account were similar to the aforementioned results for the Wt parameter, namely 36-38% lower.

Measuring points

For the finish line, which is a particularly important area from a clinical point of view, it must be noted that the values for the waviness parameters Wt and RSm were always larger for torpedo-shaped than for the cylinder-shaped COOL diamond rotary instruments. This was also the case in an internal comparison of the medium grit diamond rotary instruments, as well as within the fine grit ones.

DISCUSSION

Methodological aspects

In order to increase the conclusiveness of the quasi-experimental study, the study conditions were designed to be clinically adequate and great care was taken to homogenize the test conditions [30, 31]. However, the influence of different test subjects must be mentioned. In addition, the shape of the objects being prepared may have had an influence. The preparations executed on the ceramic blocks were done on a level surface, while clinical preparations are done on objects similar to "cylinder" stumps. The direction of measurement on the surfaces necessary for the topic selected in order to examine contact grinding and non-contact grinding for waviness parameters in a comparison must also be emphasized (see Figure 5). According to ISO directives [28, 29], the direction of measurement must be selected vertical to the surface changes to be expected (waviness or roughness). This is why the measurement took place from occlusal to finish line in the extensive literature mentioned at the beginning of the paper. For our subject, the direction had to be implemented "circular" (relative to a tooth stump). This must be noted in comparisons with other studies [13]. As there is no study with this selected direction of measuring and the analysis parameters Wt and RSm, the data cannot be directly compared.

Drives

It must be noted that no "completely smooth" (even) surfaces resulted after preparation with the spot-contact method or with contact grinding using the selected drives. However, the drives that facilitated contact grinding very frequently led to significantly smaller surface "form errors". This was documented for the total waviness and mean width of the waviness profile element parameters. Smoother preparation surfaces were achieved with a micromotor than with turbines and oscillating preparation instruments [32]. When interpreting these results, it is important to state whether the turbine facilitated contact grinding, for example. Other studies focused at the effect of the partial body oscillations and noise components as stress factors in dental preparation with the various drives [33-35]. Effects of the partial body oscillations generated during the use of the dental drive can, particularly in combination with noise (the sound of turbines with ball bearings) [36], static, awkward postures and individual predispositions, lead to shifts in sensation thresholds and vasospastic reactions in the dentists' hands guiding the drives [37-39]. A Finnish working group showed that the precision grip in dentistry could trigger arthritis in the hand [40]. However, this precision grip is required, for example, to reduce the influence of the drive vibrations on the preparations as well.

With regard to the comparison of micromotors and turbines, it must be noted that micromotors have a better cutting performance than turbines under laboratory and clinical conditions [19,41].

Diamond rotary instruments

As the COOL diamond rotary instruments consistently achieved higher values for the Wt and RSm surface parameters, higher agitation of the diamond rotary instruments during preparation is probable. The difference in grit size of the diamond rotary instruments material between COOL diamond rotary instruments and those without cooling grooves only played a role in the total waviness. For the RSm parameter there was no noteworthy difference. The fact that fine grit diamond rotary instruments produce smoother preparation surfaces is known [6].

Measuring points

The clinically important finish line influences the quality of permanent dental prostheses [17, 23]. It is significant that the results for the total waviness and the mean width of waviness profile elements in comparisons within the COOL diamond rotary instruments, within the medium grit diamond rotary instruments and within the fine grit diamond rotary instruments were always higher for the torpedo shapes than for the cylindrical diamond rotary instruments. This means that the cylindrical diamond rotary instruments can be guided better on the shoulder. This results in fewer "form errors" [7]. In this connection, the vibration behavior of the drives could also play a role. Regardless of the better results for contact grinding, the preference for the option of preselecting different speeds of the micromotor must also be noted, in order to be able to shape details better at lower speeds (finish line) [21]. To guide the diamond rotary instruments better in the area of the finish line and to prevent injuries of the marginal periodontium, shapes were implemented as self-limiting diamond rotary instruments [42].

Assessment of the hypotheses

The following theses are hypothesized: The waviness parameters of the prepared surfaces differ depending on the use of drives that do or do not facilitate contact grinding. The waviness parameters differ significantly between turbines with and without the option of contact grinding. When micromotors are used, waviness parameters for the prepared surfaces are generated that correspond to those of the newer turbines (GENTLEforce 7000 B). After the use of micromotors, waviness parameters that significantly differ from those after the use of older turbines (Super All Air 631) are generated. The additionally tested influence of selected types of diamond rotary instruments only differed between medium grit and fine grit diamond rotary instruments.

Clinical implication

Currently, the single term "turbine" no longer suffices to describe this form of drive functionally. Micromotors with speed-enhanced contra-angle handpieces and turbines which make contact grinding possible enable less waviness on prepared surfaces. Smoothing of marginal imperfections (finish line) is necessary above all in the use of torpedo-shaped grinders.

The large figures for the waviness parameter must be seen in relation to the convergence of the prepared tooth surfaces. In literature large convergence angles are portrayed in crown preparations. Convergence angles from 5 to 10 degrees are described as being ideal. Currently, convergence angles of up to 24 degrees are determined [43, 44]. For this reason, the significant differences in waviness of the surfaces hardly have any clinical importance.

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Conflict of interest

The authors declare that there is no conflict of interest.

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