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 material [12, 13]. Other studies looked at the effect of temperature on the pulp during preparation [14-16]. The quality 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 dental science.
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 is feldspat ceramic. The manufacturer characterizes these 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.

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

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

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 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 4 GENTLEforce 7000 B turbine with the corresponding MULTIflex LUX coupler
intended to ensure an ergonomic sitting posture [25]. The simulation of clinical activities was absent. All test subjects at 7:30 a.m., so that physical stress due to other procedures was minimal. 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 procedures was minimal. All 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 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 4288 [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 = 0.050).

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.

<table>
<thead>
<tr>
<th>Type of diamond rotary instrument</th>
<th>Basic design</th>
<th>Roughness</th>
<th>Grit [µm]</th>
<th>Designation / ISO – number:</th>
<th>Abbreviation used in tables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cool – diamond rotary instrument</td>
<td>torpedo</td>
<td>medium</td>
<td>90 - 125</td>
<td>CD 69 014 /#</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>CD 25 014 /#</td>
<td>B</td>
</tr>
<tr>
<td>Diamond rotary instrument without cooling grooves</td>
<td>torpedo</td>
<td>medium</td>
<td>90 - 125</td>
<td>878 014 / ISO: 806</td>
<td>C</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>314 289 524014</td>
<td></td>
</tr>
<tr>
<td></td>
<td>fine</td>
<td></td>
<td>30 – 50</td>
<td>887 8014 / ISO: 806</td>
<td>D</td>
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<tr>
<td></td>
<td></td>
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<td></td>
<td>314 289 514 014</td>
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</tr>
<tr>
<td>Cylinder with rounded edge</td>
<td></td>
<td></td>
<td></td>
<td>837 KR 014 / ISO:</td>
<td>E</td>
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<tr>
<td></td>
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<td>806 314 158 524 014</td>
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<tr>
<td></td>
<td>fine</td>
<td></td>
<td>30 – 50</td>
<td>8837 KR 014 / ISO:</td>
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<td></td>
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<td>806 314 158 514 014</td>
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</tr>
</tbody>
</table>

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.

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Drives
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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 surface) and DFL (distant to finish line smooth area) for all types of drives and diamond rotary instruments [µm]:

| MEASURING POINTS/DIAMOND ROTARY INSTRUMENTS | FL / A | FL / B | FL / C | FL / D | FL / E | FL / F | NF / A | NF / B | NF / C | NF / D | NF / E | NF / F | DF / A | DF / B | DF / C | DF / D | DF / E | DF / F | NF / F | DF / F |
|--------------------------------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| FL | 1.22 | 16.16 | 16.16 | 15.80 | 10.21 | 16.16 | 15.20 | 11.19 | 12.15 | 13.18 | 14.12 |<.001 s. | 1 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
| DFL | 1.19 | 15.15 | 15.15 | 13.13 | 9.18 | 17.17 | 14.16 | 15.11 | 16.17 | 13.13 |<.001 s. | 1 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
| FL | 1.00 | 0.10 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |<.001 s. | 1 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
| NFL | 1.10 | 0.10 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |<.001 s. | 1 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
| DFL | 1.00 | 0.10 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |<.001 s. | 1 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |

Each type of diamond rotary instrument and at each 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 drives 1 – micromotor with speed-enhancing contra-angle piece; 2 – Turbine Super – All – air 633; 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, medium roughness; E – diamond rotary instruments without cooling grooves, cylinder, medium roughness; F – diamond rotary instruments without cooling grooves, cylinder, fine roughness.

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:

| MEASURING POINTS/DIAMOND ROTARY INSTRUMENTS | FL / A | FL / B | FL / C | FL / D | FL / E | FL / F | NF / A | NF / B | NF / C | NF / D | NF / E | NF / F | DF / A | DF / B | DF / C | DF / D | DF / E | DF / F | NF / F | DF / F |
|--------------------------------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| FL | 1 – 2 | <.001 s. | <.001 s. | <.001 s. | .138 | <.001 s. | <.001 s. | <.001 s. | <.001 s. | <.001 s. | <.001 s. |<.001 s. | 1 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
| NFL | 1 – 2 | <.001 s. | .001 s. | <.001 s. | <.001 s. | <.001 s. | <.001 s. | <.001 s. | <.001 s. | <.001 s. | <.001 s. |<.001 s. | 1 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
| DFL | 1 – 2 | <.001 s. | <.001 s. | <.001 s. | <.001 s. | <.001 s. | <.001 s. | <.001 s. | <.001 s. | <.001 s. | <.001 s. |<.001 s. | 1 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |

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 instruments correspond to those in table 2.

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:

| MEASURING POINTS/DIAMOND ROTARY INSTRUMENTS | FL / A | FL / B | FL / C | FL / D | FL / E | FL / F | NF / A | NF / B | NF / C | NF / D | NF / E | NF / F | DF / A | DF / B | DF / C | DF / D | DF / E | DF / F | NF / F | DF / F |
|--------------------------------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| FL | 1 – 2 | <.001 s. | <.001 s. | <.001 s. | <.002 s. | <.001 s. |<.001 s. | 1 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
| NFL | 1 – 2 | <.001 s. | <.001 s. | <.001 s. | <.001 s. | <.001 s. |<.001 s. | 1 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
| DFL | 1 – 2 | <.001 s. | <.001 s. | <.001 s. | <.001 s. | <.001 s. |<.001 s. | 1 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |

Results achieved with the micromotor and the newer turbine were confirmed for the clinically important area of the finish line. If one compares 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.
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 measurement 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. Thewaviness 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.
The authors declare that there is no conflict of interest.

REFERENCES