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The Effect of Optical Profilometry on Dental Materials

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Abstract

The goal of this study was to use a non-contact laser profilometer (NCLP) to evaluate the digitalization behavior of various dental materials. Glass slab was used to generate standardized surface features after three kinds of dental stone Type III, Type IV, and Type V high-strength dental stone and fifteen imprint ingredients were mixed according to the directions of the manufacturers. The surface roughness parameters Ra, Rq, and Rt were calculated using 20 randomly chosen transverse profiles after the NCLP analyzed a 6 × 40 mm scan region from every sample. After that, the impression materials were filled with dental stone called Silky-RockTM (Whip Mix Corp., Louisville, KY, USA), and the casts were measured for roughness in the same way. The statistical study of differences in roughness between materials was conducted using one-way ANOVA, while the comparison of impression materials to their matching stone casts was done using a paired t-test. There were statistical differences ($p < 0.05$) in each group (impression materials and dental stones) between the various tested materials. The dental stones had surface roughness values that varied from 0.84 to 1.08 µm, Rq values from 1.06 to 1.31 µm, and Rt values from 5.48 to 6.83 «m. From 0.73 to 4.62 µm, Rq from 0.93 to 6.19 µm, and Rt from 4.61 to 39.54 µm were the roughness values for the impression materials. Dark colored impression materials had a significantly different roughness value compared to lighter color ones ($p < 0.05$). The Silky-RockTM castings had roughness values ranging from 0.80 to 1.04 µm for Ra, 1.01 to 1.27 µm for Rq, and 5.01 to 6.34 µm for Rt. After replication in many impression materials, Silky-RockTM dental stone showed a statistically significant reduction in roughness change ($p<0.01$). Optical profilometry digitization accuracy was affected by material properties such as surface texture, translucency, and color of dental stones and impression materials.

Introduction

Several studies have been conducted using surface mapping systems to investigate tooth wear in vitro [1,2], in situ [3,4], and in vivo [5,6]. Additionally, these methods have been utilized to quantify the wear attributes of restorative dental materials [7]. It is possible to construct a digital cloud of points that represents the surface topography of teeth or dental materials by utilizing touch and optical profilometers to measure sequential surface profiles. The set of points that are obtained from this process may then be linked together to form the cloud. In most cases, profilometers are utilized to scan casts of teeth that have been made from a dental impression [5,8]. These casts are typically formed using a gypsum-based dental stone [9] or epoxy resin material with or without an electroconductive covering [10]. Profilometers are not directly employed to scan teeth in vivo. In vitro profilometric analysis, on the other hand, has the capability of directly scanning the teeth that have been extracted, which helps to reduce the likelihood of making mistakes during the imprint and casting stages [2,3,11-13]. Both forms of contacting and non-contacting profilometers have been effectively described in the literature [5–7,12,14]. However, there is not yet a clear consensus on which type of profilometer is the most effective for precisely measuring tooth wear and surface properties. Contact profilometers are not capable of measuring features that are smaller than the

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diameter of the stylus probe at the instrument, which is typically between 100 and 500 µm. In addition, the topography of the specimen is recorded by applying a certain force to its surface. This force has the potential to influence the specimen or cause it to be abraded, depending on whether the specimen is a dental stone or an imprint material. By virtue of their non-contact measurement methodology and the light spot diameter that is normally utilized, optical profilometers possess the advantage of overcoming a number of these constraints. This is because the light spot diameter that is typically utilized is less than 100 µm. In optical systems, it is possible to make use of a triangulation laser sensor that measures surface topography by detecting the deflection of laser spots using a CCD camera, as well as a white light sensor or laser sensor that is based on the confocal principle to measure surface topography [15]. Measurements made using optical systems are susceptible to being influenced by the microgeometry, reflectance, transparency, and angle of the surface that is being scanned [16]. This is one of the disadvantages of optical systems.
There is a specific wavelength that is emitted by laser profilometers, and this wavelength is absorbed or reflected in a distinct manner depending on the optical qualities, color, and transparent properties of the material that is going to be scanned [17,18]. It is very important to consider the surface characteristics of gypsum products while doing research on dental materials since these characteristics have an impact on the precision of dental prosthesis, dimensional stability, and the precision of CAD/CAM scanning operations. Therefore, to improve digital dental work, it is necessary to investigate the interaction that occurs between an optical scanning system and the dental stone materials that are available.
With the help of an optical laser profilometer, the purpose of this study was to investigate the impact that the color, translucency, and surface characteristics of impression materials and three different types of dental stone (Type III dental stone, Type IV dental stone, and Type V high strength dental stone) have on the precision of surface digitization. There would be no significant difference between the optical scans that were digitized under different color, translucency, and type of dental stone materials, as well as the surface roughness parameters that were measured under the conditions that were described above, according to the null hypothesis.

Materials and Methods

Reproductions of Surface Detail by the NCLP

Three different dental stone materials were utilized (Table 1), vacuum-mixed in accordance with the instructions provided by the manufacturer, poured into a glass block that was clean and smooth, and allowed to set for a period of thirty minutes. This was done to duplicate the surface characteristics. DeLong et al. (2001) served as the foundation for the protocol, which was then adjusted to accommodate the current experiment. To prevent any intermixing from taking place, the stone components were segregated from one another. The composite slab that was produced as a result, which contained all three dental stones, was referred to as the "dental stone slab." For the purpose of simulating the surface qualities of the materials (Table 2), fifteen different impression materials were also manipulated in a manner that was comparable to the glass block. These materials were obtained from five different manufacturers. Each of the three impression slabs, which were approximately 128 millimeter in length and 92 millimeter in width, included five different imprint materials. A non-contacting laser profilometer (NCLP) model Xyris 2000TL, manufactured by Taicaan® Technologies in Southampton, United Kingdom, was utilized to perform a scanning process on the surfaces of the different materials. These materials included dental stones as well as impression materials. A section measuring 6 mm × 42 mm was scanned, and the step-over distance was 48 µm. The scanning was performed over this larger region. During the process of scanning, which involved scanning along the X-axis, the samples were scanned under the sensor at a maximum table speed of 1.4 millimeter per second. This was done to ensure that the correct results were obtained. The National Center for Laser Physics (NCLP) was outfitted with a laser triangulation sensor that possessed a wavelength of 785 nanometers, a spot diameter of 32 micrometers, and a resolution of 0.1 micrometers for both the axis and the sensor. Following the application of a Gaussian filter with a cut-off of 0.8 millimeter using BoddiesTM surface metrology software version 1.82 (Taicaan® Technologies, Southampton, United Kingdom), the surface roughness parameters Ra, Rq, and Rt were computed using 22 randomly selected transverse profiles of each scanned material. Performing this action was done with the purpose of determining the surface roughness metrics. After conducting an initial evaluation of the roughness of the three different dental stone materials that were cast against the glass block, the findings indicated that the Silky-RockTM dental stone (Whip Mix Corp., Louisville, Kentucky, United States) had the lowest overall roughness values. Because of this, this material was chosen to be used for the impression slabs. The three impression material slabs were cast in Silky-RockTM dental stone in a sequential manner, and the casts that were produced therefore corresponded to each impression material. The NCLP settings that were used were the same as those mentioned before. In this second round of measurements, the surface roughness was determined by selecting 22 transverse profiles at random and taking them along each of the cast specimens.

The accuracy of the NCLP

To evaluate the precision of the NCLP in the measurement of the Ra value, an imprint was obtained from a Ra value roughness standard, specifically the Taylor Hobson Reference Specimen Type 112/1534, which had a roughness of 6.2 µm Ra. An impression was made using light-bodied impression material, ExtrudeTM, manufactured by Kerr Corporation in Romulus, Michigan, United States of America. The impression was scanned using the same NCLP settings that were utilized in the previous section. Following the application of the identical Gaussian filter and cut-off values, the Ra roughness parameter was computed using 22 transverse profiles that were chosen at random. During these testing, the data for the medians and interquartile ranges for the roughness of the impression materials and the Silky-RockTM castings that corresponded to them did not follow a normal distribution. The one-way analysis of variance (ANOVA) was utilized to assess the differences in roughness values that were observed between the various impression materials and the various types of dental stone. Before beginning the statistical analysis, each of the roughness values was converted into logarithmic values to normalize them. Following the discovery of a significant difference between the groups, the Scheffé tests were utilized to make comparisons between them. For statistical significance, a p value of less than 0.05 was significant. To compare the differences in roughness values between the impression materials and their related Silky-RockTM dental stone castings, paired t-tests were utilized. To take into consideration the possibility of multiple comparisons, the statistical significance threshold for paired comparisons was determined to be $p<0.01$.

Results

Reproduction of Surface Detail by the NCLP

The mean surface roughness values and standard deviations of the three distinct types of dental stone materials are presented in Table 4. These three varieties of dental stone are Type III dental stone, Type IV dental stone, and Type V high strength dental stone. Variations in roughness values were observed, with Ra ranging from 0.85 to 1.03

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µm, Rq ranging from 1.07 to 1.29 µm, and Rt ranging from 5.58 to 6.73 µm. These values were observed among the roughness values. When it came to the roughness parameter, which includes Ra, Rq, and Rt, each dental stone material revealed a wide variety of individual variances. When the level of hardness of the dental stone is increased, the roughness value of the dental stone also increases in proportion to this improvement. In the study, it was discovered that the level of hardness of dental stones of type V was much higher than that of dental stones of type III and type IV, with a statistically significant difference ($p < 0.05$). Furthermore, in contrast to the other materials that were investigated, the surface of the Type V dental stone appeared to be darker than the other materials. After being measured, it was found that the rough parameters of the Type III and IV dental stones did not differ from one another ($p > 0.05$). This was the conclusion reached by the researchers. To determine the surface roughness of 15 distinct imprint materials and the Silky-RockTM dental stone castings that corresponded to them, a non-contacting laser profilometer (NCLP) was utilized. In Table 4, the median values and interquartile ranges of the surface roughness parameters (Ra, Rq, and Rt) are presented. These values are derived from the measurements that were taken. There were fourteen addition-cured silicones among the impression materials that were evaluated, and one of them was based on polyether. This substance was called ImpregumTM, and it was manufactured by 3M ESPE in St. Paul, Minnesota, with headquarters in the United States. The materials that were employed to generate the impression presented a wide array of colors, ranging from a dark purple to a light blue (Table 2). On the list of substances that were evaluated, there were four materials with a consistency like putty, two materials with a heavy body, three materials with a medium body, and six materials with a light body. The roughness values (Ra, Rq, and Rt) of the impression materials that were evaluated showed some statistically significant differences, with some materials displaying values that were much higher than others (Table 4). These discrepancies between the roughness values were observed in the impression materials. Each impression material's roughening metrics were consistent with one another throughout the procedure of several scans. This was the case throughout the entire process. The roughness values that were between the range of Ra = 0.72 to 4.63 µm, Rq = 0.91 to 6.34 µm, and Rt = 4.62 to 39.88 µm were the ones that comprised the median roughness values. The median values for the roughness parameters (Ra, Rq, and Rt) in the case of the Silky-RockTM dental stone castings ranged from 0.79 µm to 1.02 µm, 1.00 µm to 1.26 µm, and 4.96 µm to 6.44 µm, respectively. These values were determined by analyzing the average values of the roughness parameters. After conducting an analysis of the roughness parameters' average values, these values were found to be appropriate. A statistically significant variance ($p < 0.05$) was observed between the roughness parameters (Ra, Rq, and Rt) and the consistency of the impression materials. These variations were observed to be statistically significant. The materials that had the roughest texture were putty consistency materials, medium-bodied materials, and heavy-bodied materials. Putty consistency materials were the most used. There was no statistically significant difference between putty and light-bodied materials in terms of Ra ($p = 0.91$), Rq ($p = 0.85$), or Rt ($p = 0.98$). There were no differences between the two that could be considered statistically significant. This was in addition to the fact that the color of the impression materials related to significant changes in roughness. In comparison to the lighter-colored materials, such as Express™ putty, 3M ESPE, light-bodied materials, President™ putty, Coltene-Whaledent, Alstatten, Switzerland, and Extrude™ light-bodied material, Kerr Corporation, Romulus, Michigan, United States of America, the darker materials, such as Aquasil™ Ultra Monophase DECA, Dentsply Caulk, Milford, Delaware, United States of America, and Doric™ Monophase, Davis Schottlander & Davis Ltd., Letchworth, England, exhibited significantly higher roughness values (Ra, Rq, and Rt) ($p < 0.05$). The three materials that left the least impression were not distinguished from one another in any way that could be regarded statistically significant. In the case of ExpressTM putty (3M ESPE, St. Paul, Minnesota, United States), ExtrudeTM light-bodied material (Kerr Corporation, Romulus, Michigan, United States), and PresidentTM putty (Coltene-Whaledent, Alstatten, Switzerland), there was not a statistically significant difference found in roughness parameters (Ra, Rq, and Rt) between the impression materials and their respective Silky-RockTM casts ($p > 0.01$). This was the case for all three types of putty. On the other hand, it was discovered that the roughness values that were generated from the ExpressTM light-bodied material (3M ESPE, St. Paul, Minnesota, United States) were much lower when compared to the Silky-RockTM cast that was matched ($p < 0.01$). It was noted that the remaining impression materials displayed considerably higher roughness values when compared to their Silky-RockTM casts, and this difference was statistically significant ($p < 0.05$). To add insult to injury, the roughness values (Ra, Rq, and Rt) that were obtained from each Silky-RockTM cast were equivalent to those that were obtained from the Silky-RockTM dental stone slab for the sake of comparison.

The accuracy of the NCLP

The mean Ra value and standard deviation of the impression made from the roughness standard of 6.2 µm were found to be 4.07 µm ± 0.34, indicating that the non-contacting laser profilometer measurement exhibited a high level of accuracy and reproducibility.

Discussion

Given that the roughness values acquired from the non-contacting laser profilometer (NCLP) were influenced by the imprint materials and dental stones that were tested, it is possible that there was an interaction between the laser sensor and the test materials. DeLong et al. (2001) conducted research in which they used an optical white-light scanner to investigate several different impression materials. They discovered that there was no obvious connection between the color of the impression material and the way it behaved when it was digitized. The current experiment, on the other hand, demonstrated that the transparency and color of the material had a considerable influence on the laser-based optical scanning. Regarding the effect of color and transparency of dental materials on laser profilometry digitization, this is one of the first research that we are aware of reporting on the subject. In this investigation, the methodology employed was comparable to the one that had been described by DeLong et al. (2001), but it was altered to accommodate the experimental design that was utilized. Because of its low porosity and exceptional smoothness when viewed under an optical microscope, the polished glass slab was selected as the medium of choice. Due to the glass's great reflectivity and transparency, the NCLP was unable to do direct scanning of the surface of the glass. The optical constraints of the laser sensor hindered the possibility of directly scanning the glass slab, which would have allowed for a more precise comparison to be made between the reference surface and the materials that were being evaluated. For this research project, the impression materials that were selected were those that are commonly utilized in the field of restorative dentistry and encompassed a wide range of colors and variations in consistency. The same thing happened with three other types of dental stone: Type III dental stone, Type IV dental stone, and Type V high strength dental stone. The purpose of these studies was to determine how the opacity and composition of the material affected the digitization behavior of the optical profilometer. To evaluate the surface detail features and the interaction

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between the laser light and the materials that were being tested, surface rough parameters such as Ra, Rq, and Rt were calculated and measured. Rq is the root mean square of the peaks and valleys in the profile that was scanned, but Rt is the distance between the highest peak and the lowest valley in the surface profile. Ra is the average of the peak values from the surface profile, minus the valley values that correspond to those peak values. The roughness measurements that were obtained through the usage of the impression that was made by the NCLP roughness standard demonstrated that the NCLP has an exceptional level of measurement accuracy. The Ra value that the system produced was approximately 6.04 µm, with a standard deviation of ±0.31. The mean departure from the reference standard was almost 0.02 µm, which indicates that the system produced a low divergence from the standard. Reliability and repeatability of the NCLP for surface characterization studies have been demonstrated to be supported by the findings that have been provided here. Furthermore, it is worth noting that the laser sensor possessed a relatively very small spot size, measuring approximately 32 µm. However, due to its high vertical resolution of 0.1 µm, it was able to detect extremely minute vertical surface features. Both light absorption and light reflection from a material surface are significantly impacted by the wavelength of the laser that is being emitted as well as the optical properties of the material. To this investigation, the NCLP made use of a laser sensor that had a wavelength of 785 nm, which is somewhat closer to the infrared part of the electromagnetic spectrum. It is possible that the much higher roughness values measured for dark-color impression materials are since the absorption of this wavelength increases in proportion to the extent to which the material's color is darker. The scanning accuracy will be partial, and the artefact will emerge in the scanning results when the material absorbs light at a frequency that is near to the frequency that is emitted by the laser sensor [17]. This will influence the accuracy of the surface characteristics that are recorded by the sensor. Different amounts of fillers, pigments, and optical modifiers are added to impression materials throughout the production process. This is done to alter the consistency of the material, make it simpler to manipulate, and improve the contrast with oral tissues. The changes can cause the material to become more opaque or more translucent, and they can allow the laser beam to pass through the surface of the material more easily or they can prevent it from doing so. Scanning artifacts, which are caused by variations in light penetration, have the potential to influence the roughness values that are assessed. Prior research [18,19] has suggested that optical scanners could be an effective instrument for analyzing materials that are opaque or non-transparent. The findings of this study not only provide credence to the observations, but they also demonstrate that color is an essential component in determining the precision of number representations. The levels of the surface roughness were also shown to have an association with the consistency of the imprint material. Heavy-bodied impression materials had higher roughness values than medium-bodied and putty materials, which had lower roughness values overall. While the materials that were employed in this investigation tended to have a darker color, the findings of this study should be regarded with caution because of this tendency. To determine the independent effect of impression material consistency on laser scanning behavior, additional tests with impression materials of varying consistencies, but with color that are comparable, would give helpful feedback. Comparatively, the roughness values of the dental stones that were examined were comparable to those of the impression materials, and the roughness measurements were, on average, lower. Since dental stones have a higher level of opacity than impression materials, they were able to produce more accurate reproductions of their optical properties when they were scanned with a laser. Based on the results of the impression materials, it was discovered that the dental stone with the highest hardness (Type V) also had the highest roughness values and was the darkest of the ones that were evaluated. To produce impression casts, the Type IV dental stone was selected since it had the lowest overall roughness values. As a result, it was selected for this purpose. The procedure of recovering impression materials from dental stone casts was another factor that influenced the roughness measurement values. Dental stone casts were also used to duplicate the impression materials, which had an impact on the roughness values that were first measured. There was a considerable decrease in the roughness values of AquasilTM Ultra Monophase DECA (Dentsply Caulk, Milford, Delaware, United States) after the creation of Silky-RockTM dental stone. These values were the highest. Therefore, it may be inferred that certain impression materials have the potential to generate optical errors even when direct scanning is performed. However, this potential can be mitigated by reproducing the impressions in dental stone. There was, on the other hand, no statistically significant difference between the roughness values that were directly taken from the impression materials and the corresponding Silky-RockTM casts for ExpressTM putty (3M ESPE, St. Paul, Minnesota, United States), PresidentTM putty (Coltene-Whaledent, Alstatten, Switzerland), and ExtrudeTM light-bodied material (Kerr Corporation, Romulus, Michigan, United States). The findings of this research indicate that casts of impressions and impression scanning might be accomplished with a high degree of precision without having a significant effect on the dimensions of the surface. On the other hand, when compared to the identical dental stone cast, the roughness value of the ExpressTM light-bodied material was reduced by a marginal amount. Prior to using dental materials for precise and repeatable digital scanning in optical surface analysis research, particularly in tooth wear assessment studies and surface characterization investigations, it is imperative that the materials be evaluated and standardized according to the appropriate standards. Several of the impression materials that were examined in this work exhibited roughness values that were close to 32 µm. These values have the potential to be misconstrued as genuine surface characteristics in wear tests, which typically employ thresholds that are approximately 30 µm in size. As a result, when doing research using optical profilometers, it is strongly suggested that materials be chosen based on the optical and surface characteristics of the materials. A variety of different dental materials that are scanned with an optical or laser could potentially be tested using the testing process that is described in this article.

Conclusion

There were statistically significant differences in the surface roughness characteristics (Ra, Rq, and Rt) among the dental materials that were evaluated. These materials included impression materials as well as three different types of dental stone: Type III dental stone, Type IV dental stone, and Type V high-strength dental stone. These changes were not due to actual variances in surface topography; rather, they were mostly associated with the optical qualities of the materials, which included the color, opacity, and translucency of the materials. The digitized surface measurements that were acquired with the non-contacting laser profilometer (NCLP) revealed that the darker and more translucent materials exhibited a greater degree of differentiation. The findings of this study provide evidence that the color and transparency of dental materials have a considerable influence on digitized laser scans, which in turn can influence the accuracy and reproducibility of optical surface analysis. Consequently, when doing research utilizing laser-based profilometry and digital surface characterizations, it is essential to select

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dental materials appropriately and to standardize them whenever possible.

Conflict of Interest
The author has no conflict to declare.

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Table 1. Dental stone materials used in the study.

Dental stones materials	Manufacturers	Colors	Lot/Exp
Type III dental stone (Microstone™)	Whip Mix Corp., Louisville, KY, USA.	Light beige	071245/April 2027
Type IV dental stone (FujiRock™)	GC Europe, Leuven, Belgium.	Pale yellow	061278/June 2028
Type V high-strength dental stone (Silky-Rock™)	Whip Mix Corp., Louisville, KY, USA.	Light brown	60512/Jan 2027

Table 2. Impression materials used in the study.

Impression materials	Manufacturers	Consistency / Colors	Lot/Exp
Affinis (heavy bodied)	Coltene-Whaledent, Switzerland.	Heavy / dark brown	009721/Jan 2027
Affinis (light bodied)	Coltene-Whaledent, Switzerland.	Light / green	009464/June 2027
Aquasil (Ultra monophas DECA)	Dentsply Caulk, USA.	Medium / purple	061412/May 2028
Aquasil (LV light bodied LV)	Dentsply Caulk, USA.	Light / blue	060418/June 2027
Aquasil (putty)	Dentsply DeTrey, Germany.	Putty / blue	060645/Feb 2028
Doric (monophas)	Davis Schottlander, England.	Medium / violet	570921/Sep 2027
Express (light bodied)	3M ESPE, USA.	Light / blue	4HLF29/Mar 2028
Express (putty)	3M ESPE, USA.	Putty / clay	8JM42/Sep 2027
Extrude (light bodied)	Kerr Corporation, USA.	Light / pale blue	63328/Mar 2027
Extrude (putty)	Kerr Corporation, USA.	Putty / purple	537612/Jan 2028
Impregum™	3M ESPE, USA.	Medium / purple	25515/July 2027
President (Jet light bodied)	Coltene, Switzerland.	Light / green	008945/June 2028
President (putty)	Coltene, Switzerland.	Putty / mustard	011012/Feb 2028
Take1 (heavy bodied)	Kerr Corporation, USA.	Heavy / blue	63218/Dec 2026
Take1 (light-bodied)	Kerr Corporation, USA.	Light / orange	64402/Mar 2027

Table 3. The mean and (standard deviation) surface roughness values (Ra, Rq and Rt) of dental stone materials.

Dental stone material	Ra (µm)	Rq (µm)	Rt (µm)
Type III dental stone (Microstone™)	0.91 (0.07)	1.15 (0.08)	6.11 (0.74)
Type IV dental stone (FujiRock™)	0.86 (0.05)	1.08 (0.06)	5.63 (0.69)
Type V high-strength dental stone (Silky-Rock™)	1.02 (0.11)	1.28 (0.14)	6.74 (1.08)

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Table 4. Median (interquartile ranges) of surface roughness values Ra, Rq and Rt of impression materials measured by the non-contacting laser profilometer (Taicaan™–Southampton) and their corresponding Silky-Rock™ dental stone casts.

	Ra (μm)		Rq (μm)		Rt (μm)	
impression materials	Impression materials	Silky_Rock	Impression materials	Silky_Rock	Impression materials	Silky_Rock
Affinis(heavy bodied)	1.69 (1.6–1.8)	0.82 (0.78–0.87)	2.18 (2.08–2.35)	1.05 (0.97–1.1)	11.42 (10.55–13.96)	5.12 (4.68–5.60)
Affinis(light bodied)	1.12 (1.01–1.26)	0.86 (0.8–0.91)	1.42 (1.3–1.6)	1.08 (1.03–1.15)	7.26 (6.55–9.08)	5.48 (5.02–5.95)
Aquasil(LV light bodied)	1.81 (1.66–1.93)	0.89 (0.82–0.94)	2.31 (2.1–2.44)	1.09 (1.0–1.17)	12.16 (11.05–14.18)	5.33 (4.82–5.81)
Aquasil(putty)	1.01 (0.91–1.09)	0.94 (0.85–0.99)	1.31 (1.19–1.46)	1.15 (1.08–1.22)	7.03 (6.6–9.04)	5.61 (5.31–6.1)
Aquasil(DECA)	4.48 (4.24–4.96)	0.95 (0.86–1.01)	6.14 (5.78–6.69)	1.17 (1.08–1.25)	38.85 (33.4–45.72)	5.81 (5.37–6.38)
Doric(monophas)	1.95 (1.82–2.11)	0.86 (0.81–0.93)	2.64 (2.49–3.02)	1.08 (1.0–1.16)	15.82 (14.2–21.9)	5.62 (5.02–6.05)
Express(putty)	0.85 (0.76–0.9)	0.91 (0.83–0.97)	1.07 (0.96–1.13)	1.14 (1.04–1.2)	5.42 (5.01–5.75)	5.71 (5.21–6.25)
Express(light bodied)	0.8 (0.76–0.84)	0.88 (0.84–0.92)	0.99 (0.95–1.03)	1.1 (1.06–1.16)	4.95 (4.5–5.35)	5.42 (5.06–5.9)
Extrude(light bodied)	0.78 (0.72–0.83)	0.83 (0.79–0.88)	0.98 (0.92–1.03)	1.03 (0.99–1.08)	4.86 (4.52–5.62)	5.20 (4.75–5.44)
Extrude(putty)	1.18 (1.1–1.3)	1.0 (0.96–1.05)	1.55 (1.48–1.69)	1.24 (1.19–1.33)	8.34 (7.75–9.36)	6.45 (5.28–6.95)
Impregum	1.26 (1.18–1.33)	0.93 (0.88–1.01)	1.63 (1.52–1.69)	1.16 (1.11–1.24)	8.52 (7.64–9.33)	5.98 (5.2–6.42)
President(JET light bodied)	1.04 (0.96–1.11)	0.93 (0.86–0.99)	1.29 (1.22–1.39)	1.17 (1.08–1.23)	6.66 (6.02–7.33)	5.53 (5.22–6.2)
President™ putty	0.95 (0.88–1.01)	0.98 (0.94–1.03)	1.21 (1.12–1.28)	1.23 (1.18–1.28)	6.28 (5.84–7.3)	6.31 (5.92–6.82)
Take1™ light-bodied	1.61 (1.49–1.86)	0.91 (0.87–0.95)	2.08 (1.99–2.44)	1.13 (1.07–1.19)	12.26 (10.08–13.82)	5.66 (5.31–6.34)
Take1™ heavy-bodied	1.68 (1.6–1.84)	0.9 (0.84–0.94)	2.24 (2.03–2.46)	1.09 (1.03–1.16)	13.04 (11.74–14.82)	5.88 (5.4–6.51)