Surface Roughness of Dental Porcelain Fused-To-Nickel Chromium Using Different Polishing Materials and Glazing Techniques

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ABSTRACT

Background: Rough dental porcelain surface due to incorrect glazing technique or occlusal adjustment can cause wear of opposing teeth and tissue irritation. The aim of this study was to measure the surface roughness of low-fusing dental porcelain after treatment with different polishing materials and glazing techniques.

Materials and Methods: Seventy metal-ceramic specimens were fabricated and divided into seven groups according to type of surface treatment.

Group I: Unglazed porcelain (control group).

Group II: Porcelain polished with sandblast powder and then autoglazed,

Group III: Porcelain polished with sandblast powder and then applied glaze.

Group IV: Porcelain polished with sandblast powder and then porcelain rubber wheels.

Group V: Porcelain polished with sandblast powder, porcelain rubber wheel and then polishing paste.

Group VI: Porcelain polished with sandblast powder, porcelain rubber wheels, polishing paste and then autoglazed

Group VII: Porcelain polished with sandblast powder, porcelain rubber wheels, polishing paste and then applied glazed.

The surface roughness averages “Ra” of the specimens have been determined using the profilometer.

Results: One way – ANOVA showed highly significant differences among tested groups. Group I showed roughest group with highly significant differences among all tested groups. Followed by group II with highly significant differences, then group III which showed no significant differences with group VII, which is the smoothest group scored. Also group IV showed “Ra” values compared with group VI. While group V showed slightly significant differences with group VII (LSD test).

Conclusion: Polished porcelain with (rubber wheel and polishing paste) can be considered a good alternative to applied glazed of porcelain restoration which is characterized by time consuming and sensitive technique.

Moreover, autoglazing porcelain followed by polishing or without polishing , proved to be disadvantageous since it increases surface roughness.

KEY WORDS

dental porcelain, glaze, polishing, surface roughness

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خشونة السطح للسيراميك السني المرتبط ب سبيكة نيكل كروميوم باستخدام طرق و مواد تلميع و تزجيج مختلفة

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المستخلص

تحتاج تعويضات الخزف السنية في أغلب الاحيان الى التعديل في الجانب المختبري و العيادي قبل التثبيت. هذه التعديلات تشمل ضمناً الشكل و الاطباق و تصحيح اللون و اخفاء النقائص ومن ثم التزجيج النهائي.

أن الهدف من هذه الدراسة هو قياس معدل الخشونة والصلاده لتعويضات خزف الاسنان. حيث تم تحضير سبعون عينة مربعة من المعدن المغطاة بمادة الخزف السنية ,وزعت العينات الى سبع مجاميع حسب نوع التلميع و الصقل لأسطح الخزف , وضمت كل مجموعة عشر عينات كالأتي:

المجموعة الأولى: خزف بدون تلميع أو صقل.

المجموعة الثانية: تم تنعيم الخزف بأستعمال مسحوق الصقل الرملي ثم عولج بطريقة التزجيج الحراري الطبيعي (الذاتي).

المجموعة الثالثة: تم تنعيم الخزف بأستعمال مسحوق الصقل الرملي ثم الصقل بطريقة التزجيج الحراري المضاف.

المجموعة الرابعة: تم تنعيم الخزف بأستعمال مسحوق الصقل الرملي ثم تم تلميعه بالقرص المطاطي للسيراميك.

المجموعة الخامسة: تم تنعيم و تلميع الخزف بأستعمال مسحوق الصقل الرملي ثم أستعمال القرص المطاطي للسيراميك يليه أستعمال معجون التلميع للسيراميك.

المجموعة السادسة: تم تنعيم و تلميع الخزف بأستعمال مسحوق الصقل الرملي ثم أستعمال القرص المطاطي للسيراميك يليه أستعمال معجون التلميع للسيراميك,

يليـه صقـل السـطح بالتزجيـج الحـراري الطبيعـي .
المجموعـة السـابعة: تـم تنعيـم و تلميـع الخـزف بأسـتعمال مسـحوق الصقـل الرملـي ثـم أسـتعمال القـرص المطاطـي للسيراميك يليـه أسـتعمال معجـون التلميـع للسيراميك,
يليـه صقـل السـطح بالتزجيـج الحـراري المضـاف .

عينت معدلات الخشونة لسطح العينات بواسطة مقياس الخشونة(البروفيلوميتر).

أظهـر التحليـل الأحصـائي للنتائـج أن التنعيـم و الصقـل لمـادة السـيراميك المسـتعملة في صناعـة الأسـنان هـو ظـروري جـدآ حيـث انـه يرفـع مـن كفـاءة هـذه المـادة ويطيـل مـن فـترة بقاءهـا, فقـد أظهـرت نتائـج الفحـص للأختبـارات الأحصائيـة أختبـار(ANOVA- أحـادي الأتجـاه) وجـود مسـتوى هـام جـدآ مـن الأختـلاف بين كل مـن المجموعـات السـبع.

فقـد تبـين أن المجموعـة السـابعة (تنعيـم و صقـل السـيراميك بمسـحوق الصقـل الرمـلي ثـم بالقـرص المطاطـي ثـم أسـتعمال معجـون التلميـع يليـه التزجيـج الحـراري المضـاف) هـي الطريقـة الأفضـل للحصـول عـلى أفضـل النتائـج لهـذه الدراسـة, و تلتهـا المجموعـة الثالثـة بـدون أهميـة أحصائيـة بـين معـدلات قيمهـا, ثـم المجموعـة الخامسـة بفـارق معنـوي بسـيط جـدآ مـع المجموعـة االسـابعة .

كـما أن المجموعـة الرابعـة أظهـرت معـدل للخشـونة مقـارب لمعـدل الخشـونة في المجموعـة السادسـة تلتهـا المجموعـة الثانيـة بفـارق معنـوي كبير.أمـا المجموعـة الأولى فقـد أظهـرت فارقـآ معنويـآ كبـيرآ جـدآ عنـد مقارنتـه مـع بقيـة المجاميـع بالأختبـار الأحصـائي (أقـل الأختـلاف الهـام LSD

أن الأسـتنتاجات المسـتنبطة مـن هـذه الدراسـة تبـين أن تلميـع الخـزف بمسـحوق الصقـل الرمـلي ثـم التلميـع بالقـرص المطاطـي يليـه أسـتعمال معجـون التلميـع بديـل جيـد للصقـل الحـراري المضـاف , و مـن جهـة أخـرى نجـد أن صقـل الخـزف بالتزجيـج الحـراري الطبيعـي (سـواء أجـري بعـد التلميـع أو بـدون تلميـع) غـير مفيـد لأنـه يزيـد مـن خشـونة السـطح .

INTRODUCTION

Most of the published information regarding the reaction of soft tissue around porcelain indicated that the tissue can tolerate glazed porcelain better than other materials and that oral tissue reacted most favorably to porcelain when it was highly glazede [(1)].

Dental porcelains have been modified to a state of near perfection but still they exhibit certain disadvantages. The most serious is their tendency to abrade all structure against which it occludes including natural teeth and various types of non-porcelain restorative systems [(2)].

This could be a direct result of creating rough porcelain surfaces especially following final cementation due to occlusal adjustments intraorally. Increased enamel wear of natural teeth due to abrasion by unglazed porcelain restorations have been reported [(3)].

While glazing of porcelain was estimated to prevent such hazardous results by sealing the defects in porcelain surface that could have happened during its processing [(4)].

Reports indicated that the retention of the glazed surface could be unguaranteed and could be removed under masticatory function in a short period of time [(5, 6, 7)].

Polishing unglazed porcelain surface have long evoked as an alternative to glazing and was described as to provide greater control of the surface luster distribution than glazing by which the entire crown is subjected to the same time-temperature combination [(8)].

A number of different materials and techniques for polishing adjustment porcelain surfaces have been compared with different glazing methods. Many of those works showed that polishing provided better surface topography when compared to autoglazed porcelain surfaces [(9, 10, 11, 4, 12)].

Others found no significant differences concerning surface smoothness between polishing and applied glaze of porcelain [(2, 13)].

Despite the aesthetic advantages of polished porcelain, there is concern as to whether the strength of a polished restoration might be reduced or its abrasiveness increased. Glazing has been cited as strengthening a dental porcelain restoration presumably because it causes a reduction of the flaws that initiate porcelain fracture and polishing also was described to reduce flaws [(14)].

The present study aims at measure the surface roughness of low-fusing dental porcelain after treatment with different polishing materials and glazing techniques.

MATERIALS AND METHODS

To fabricate the metal-ceramic specimens, seventy square pieces of modeling base plate wax (Hilfex, India)[1 cm in length, 1cm in width] [(15, 5)] were cut using wax cutter to uniform thickness (1.5mm) for each pattern. Every six samples were sprued by sprue wax of (2.5mm thickness) (Dentaurum, Germany) and invested in one metal casting ring (3X) (Degussa, Germany).The last four samples were sprued in the same manner.

Surface tension reducing agent (Nordenta, Germany) was sprayed on wax pattern, and left for drying for (5 min.) to minimize air-bubbles formation (16). Each casting ring was lined with dry asbestos-free liner (Kera-Viles, asbestos-free strips, Dentaurum, Germany) then phosphate-bonded investment (Free carbon, Gilvest, Germany) was mixed manually for 15 seconds followed in a vacuum automixing machine (Bego, Germany) for 45 seconds, after which the homogenous mixture was directly poured into the casting ring under vibration and was left for one hour to completely set.

Wax burn out was performed by heating each casting ring up to (200°C) for (30 min.) then to (950°C) for 1hr. in electrical furnace (Derotor , QD, England) .Before (10 min.) of ending the burn-out, the ring was inverted so that the gases could escape outside the mold. Fresh nickel-chromium alloy ceramcoalloy (Super bond , American Dent-All, USA) was casted by manual driven broken arm centrifugal casting machine (TSI, Degussa, Germany).

Afterwards, each casting ring was left for bench cooling.The metal specimens were divested, separated from the main metal sprues, then all accessories and bubbles were removed by stone burs and sandpapered (220 grit) at 1 cycle/sec. for 50 seconds and was rechecked for standardization of a flat surface at 3 points (one in the middle and 2 at the peripheries) to have 1.5 mm thickness using a metal caliper (Aesculap, Germany).

All samples were oxidized according to manufacturer's instructions, and the oxide layer on each metal sample was formed by heating it inside a computerized ceramic furnace (Vita Vacumat 200, Germany) at (960°C) for (6 min.) without vacuum.

A sandblasting machine (Minipol, Degussa, Germany) was used with sandblast powder of (50µm) aluminum oxide to control the thickness of the oxide layer [17], each sample was fixed by a holder (place inside the sandblasting machine) at a distance (5cm) away from the nozzle opening of the sandblasting machine and the distance was adjusted by using a plastic ruler fixed inside the machine, then the samples were exposed to sandblasting process for (5 sec.) under (5 bars) pressure [18].

All the samples were cleaned ultrasonically in a bath of distilled water at (70°C) for (10 min.) to be ready for porcelain buildup [19].

Opaque and body porcelain Vita 68 opaque and body porcelain kit (Vita, Germany) were applied according to manufacturer's instructions (2 opaque and 2 dentin porcelain layers each fired at 930 ºC with a one min. holding time under vacuum. The excess thickness of porcelain was removed using diamond finishing disc (Meisinger, fine, Germany) mounted on the straight hand piece at a speed of (30, 000 rpm) attached to dental surveyor under water cooling Fig (1) the total sample thickness (metal-ceramic) was 3mm (1.5 mm metal+ opaque + body porcelain).

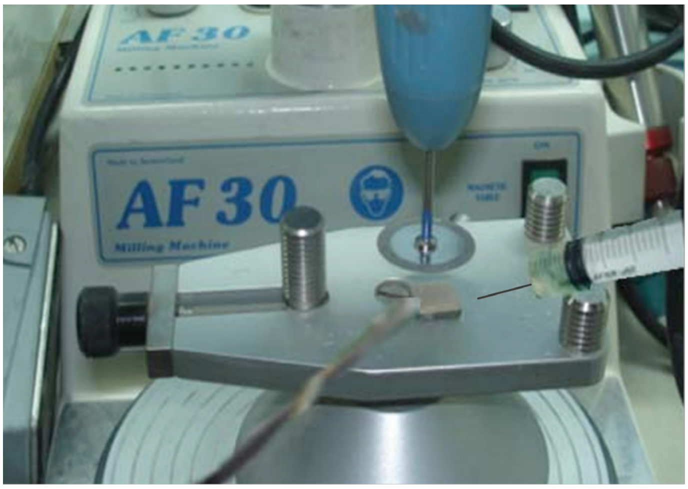

Fig. (1) Controlling the thickness of porcelain layer by using a milling machine

Then, surface roughness was measured for each sample before treatments by using a (surface roughness measuring device) profilometer machine Fig (2) (Talysurf 4 , England) [20].

Fig (3) **Surface roughness test**

Samples, which gave a roughness average (Ra) between (1.68-4.03µm), were used, and any sample with higher or lower roughness was discarded to standardize the surface topography of all samples before surface treatment.

Samples Grouping:

Seventy samples were divided into 7 groups according to the type of polishing and glazing techniques used.

Each group consisted of 10 specimens:

- Group I:Unglazed porcelain (control group) diamond disc with water used to remove any scratches or voids to produce homogenous surface and standardize the thickness of metal-porcelain thickness[16].
- Group II: Porcelain polished with sandblast powder and then autoglazed,
- Group III:Porcelain polished with sandblast powder and then applied glaze.
- Group IV:Porcelain polished with sandblast powder and then porcelain rubber wheels.
- Group V: Porcelain polished with sandblast powder, porcelain rubber wheel and then polishing paste.
- Group VI:Porcelain polished with sandblast powder, porcelain rubber wheels, polishing paste and then autoglazed
- Group VII:Porcelain polished with sandblast powder, porcelain rubber wheels, polishing paste and then applied glazed.

After complete all these procedures, the handles were cut with carbrundum disc mounted on a straight hand piece (35000 rpm) with water cooling and then, porcelain samples were placed in an oven at (600°C) for (30 min.) to relieve residual stresses that may have developed because of handle cutting procedures [21]. All samples were stored separately in air at room temperature until the final test was done.

The surface roughness was expressed as a roughness average (Ra); this is calculated by first setting up a center line so the sum of the surface profile areas above the line is equal to those below, as appeared in Fig. (2).

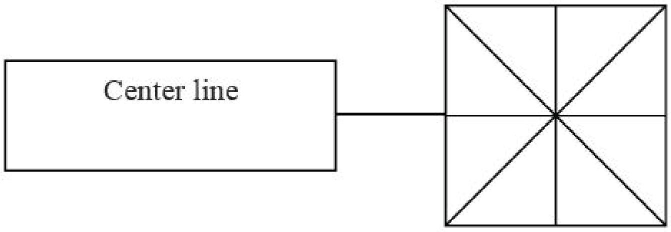

Fig. (3) The lines draw above the center line equal to those below

The (Ra) value of the surface is the average height of profile above and below the center line along a given length. The (Ra) values for all specimens have been recorded using profilometer (Talysurf 4), Fig(3). For each specimen four readings were recorded and the mean was calculated. The surface profiles of the specimen that represent the means of scores for all group were recorded, as Fig. (3), the roughness average (Ra) is the arithmetic mean of all values of the roughness profile within the measuring length (Lm) [12].

The results were recorded and analyzed statistically using a one-way Analysis of Variance (ANOVA), Least Significant Difference (LSD).

RESULTS

Table (1) shows the descriptive statistics of (Ra) values of the tested groups including arithmetic mean, standard deviation, minimum and maximum values. From Fig.(4), group VII scored the lowest mean value followed by group III and group V, while group I (control group) scored the highest mean value. Statistical analysis of (Ra) mean values of different groups using (ANOVA) test revealed that there was highly statistical significant differences at level (P<0.01) among group means as shown in table (1).

Table (1) Descriptive and Inferential statistics for surface roughness test.

Studied groups	*N*	*Mean*	*Std. Deviation*	*Std. Error*	*Minimum*	*Maximum*	*ANOVA (F-test)*
unglazed	10	2.576	0.595	0.1882	1.68	4.03	0.00 Highly Sig. (P<0.01)
auto glaze	10	0.735	0.062	0.019	0.62	0.81	
adding glaze	10	0.247	0.037	0.011	0.19	0.31	
Rubber wheel	10	0.452	0.045	0.014	0.37	0.52	
Polishing	10	0.355	0.054	0.017	0.26	0.44	
Polishing + auto glaze	10	0.453	0.050	0.015	0.37	0.53	
Polishing + adding glaze	10	0.129	0.029	0.009	0.10	0.20	
Total	70						

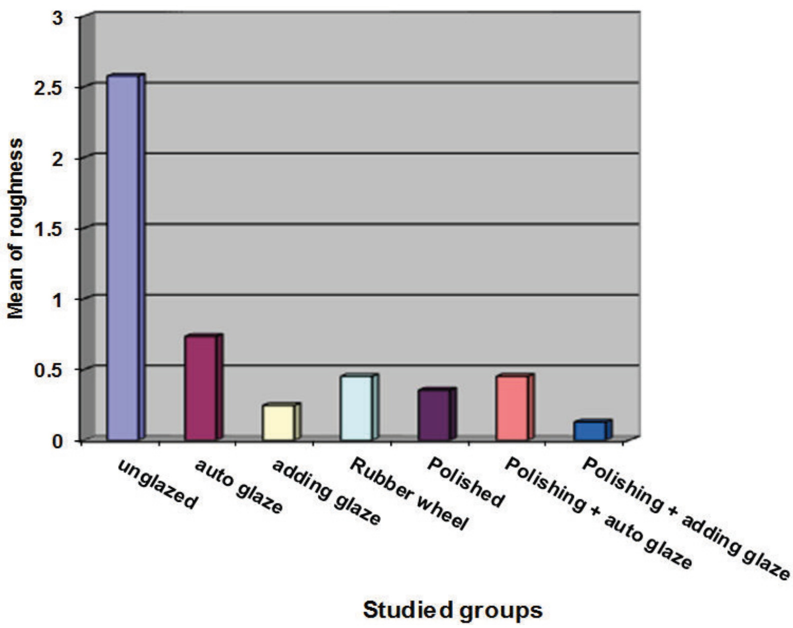

Figure (4) Bar graph represented the descriptive statistics for surface roughness test.

In order to statistically verify the significance within the different groups, a (LSD) was performed to compare pairs of (Ra) values of different groups as listed in table (2).

The LSD represented highly significant differences between groups:

- Group I with group II, III, IV, V, VI, and VII.
- Group II with group III, IV, V, VI, VII.
- Group IV with group VII.
- Group VI with group VII at level (P<0.01).

Significant difference scored between:

- Group III with group IV, VI.
- Group V with group VII at level (P<0.05).

While Non-significant differences were shown between:

- Group III with group V, VII.
- Group IV with group V, VI.
- Group V with group VI at level (P>0.05).

Table (2) the result of multiple comparison test (LSD) of surface roughness between tested materials groups.

LSD (F-test)							
groups	*Unglazed*	*Auto glazed*	*Adding glaze*	*Rubber wheel*	*Polished*	*Polishing + auto glaze*	*Polishing + adding glaze*
unglazed	-	HS	HS	HS	HS	HS	HS
auto glaze	-	-	HS	HS	HS	HS	HS
adding glaze	-	-	-	S	NS	S	NS
Rubber wheel	-	-	-	-	NS	NS	HS
Polished	-	-	-	-	-	NS	S
Polishing+ auto glaze	-	-	-	-	-	-	HS
Polishing+ adding glaze	-	-	-	-	-	-	-

DESCUSSION:

The profilometer appeared to be the ideal instrument for studying surface roughness of restorative materials, since this instrument give quantitative measurements that can be calculated and compared statistically [12].

In group I (Unglazed porcelain surface), diamond disc with water used to remove any scratches or voids to produce homogenous surface and standardize the thickness of metal-porcelain thickness [16, 12, 22].

This group showed the roughest surface with high significant difference from the rest groups. The rough surface was thought to be produced by the irregular particles and voids which were probably brought about by the removal of superficial grains during grinding. This agreed with [23, 24, 12, 13] who reported that the surface obtained by the use of fine diamonds were roughest.

In group II (Autoglazed porcelain surface). Because porcelain has the ability to glaze itself; autoglazed feldspathic porcelain was found to be much stronger than unglazed porcelain, particularly if the surface is rough. The glaze is effective in reducing crack propagation [25, 26].

This group showed a significant decrease in (Ra) values and an improvement of many voids and irregularities than group I, but it is still having a rough surface in comparison with the other groups with high significant difference, that might be due to autoglaze porcelain produced superfine pitting. Such finding was consistent with [27, 24, 12] who found that autoglazed porcelain produce surface rougher than polishing porcelain and discovered that, it is impossible to completely overcome the roughness of a surface by glazing alone, also in agreement with recent study by Anmol and Soni 2014 [28] who concluded that surface texture of the Feldspathic porcelain and fluorapatite leucite porcelain samples after finishing with different abrasive systems and polishing with diamond polishing paste was superior to auto glazed porcelain samples and disagreed with [29, 23, 30] Who found that there are no differences clinically or by means of SEM between the polished porcelain and naturally glazed porcelain.

However, some studies had shown that the generally smoothness autogenous glaze demonstrated a certain degree of residual microscopic pitting because of, during autoglazing procedure, the glass was flow and full the fine porosity present in the internal layer of fired porcelain that lead to escape the air and produce a microscopic pitting [31].

In group III (Applied glaze porcelain surface). A significant improvement of (Ra) values was found and it was the second smoothest group in this study, produced a glossy surface. Group III was smoother than group I, II, IV and VI. This result had shown a high significant difference with group I, II and significant difference with groups IV and VI and non-significant differences with group V and VII. The cause for lower values of surface roughness related to [27, 32, 33, 16, 8, 12] results who found that the applied glaze lead to seal microscopic pitting present on the porcelain surface that produce a satisfactory surface for porcelain restorations.

The non significant difference concurs with [30, 12] who stated that final glaze presents the most acceptable surface, and found as a finer abrasives are used followed by adding glaze solution produce surfaces become smoother and more regular, and found no significant difference could be observed in the quality and surface texture of polished and applied glaze porcelain.

Investigation of the glazed porcelain surface by [5] who showing that the glaze is removed in less than two hours of wear of glazed porcelain surfaces on a machine designed to simulate the masticatory cycle. They concluded that the amount of enamel wear produced by both glazed and unglazed porcelain is similar; while, that polished porcelain is substantially less.

In group IV (Rubber wheeled porcelain surface) had shown a moderately smooth surface. The (Ra) values were moderately different from group I, II and more than group III. Porcelain rubber wheels may be led to exposure to large bubbles in the surface. A finding not consistent with [29, 34, 13] who demonstrated that no difference clinically or by mean SEM between the polished and naturally glazed surfaces of porcelain, and some voids are present on the polished surface which are not evident on the glaze.

Possible explanation for this disparity was different polishing rubber wheel and different surface textures of different types of porcelain.

In group V (Polished porcelain surface), there was a high significant improvement in the (Ra) values if compared with group I, II. The roughness produced by porcelain rubber wheels may be improved by using of polishing paste. These results supported with the works of [30, 12] who found that polishing of dental porcelain scored the surface smoothness after applied glaze surface and found the surface texture produced by polishing is compared with that applied glaze, but this results in contrasted with [29] who found that there is no differences clinically or by mean of SEM between the polished and naturally glazed porcelain. Also, disagreed with [35, 36] they reported that poor performances for polishing paste used alone after being compared with autoglazing of porcelain. .

Possible explanation for this disparity was the different testing method used and different polishing paste used in the experiments.

In group VI (Polishing + autoglaze porcelain surface), the results of this group showed significantly increased in the (Ra) value than group III, VII, and improvement in (Ra) value in comparison with group I, II. A finding agreed with [37, 12] who concluded that polishing followed by self glazing produces fine surface cracks. The rougher surface resulting from the surface cracks and subsequent porcelain chipping may be caused wear of the opposing occlusal surface, so that natural glaze after polishing procedure is not satisfactory for porcelain restorations. But in contrast with [36, 37] who discovered poor performance for polishing paste compared with autoglaze.

Possible explanations for this disparity are the different testing methods used and the different surface textures of different types of porcelain.

In group VII (Polishing + applied glaze). This group had shown very high significant improvement in (Ra) values in comparison with the other group and scored the first surface smoothness among the tested groups. These results supported by investigation of [38, 39, 26, 40] who discovered that an optimum method of producing the smoothest surface in the shortest time has not been established yet. It's logical to assume that, fine polishing of a roughened surface followed by glazing produces smoother surfaces than polishing alone.

On the contrary, [11] who found that feldspathic porcelain could be polished smoother than glazed porcelain. Also, it had been reported that an alternative to glazing of porcelain, polishing of porcelain surfaces using different polishing techniques could be performed. Advantages of such method are that it affords greater control of the surface luster and distribution than does glazing.

CONCLUSION

Within the limitations of the present study, the following conclusions can be drawn:

Polishing + applied glaze group showed the highest smoothness surface values among the other groups.

Polished group would be satisfactory regarding surface smoothness values of porcelain restorations compared with samples treated (applied glaze alone) and (polishing+ applied glaze) groups.

Using applied glaze solution still the best surface quality, while natural glaze after the use of polishing paste gives bad results and polishing of porcelain with rubber wheel alone was of no benefits for porcelain restorations.

The higher surface roughness values were recorded by (autoglazed porcelain alone); while the control group (unglazed porcelain) showed the highest surface roughness values.

Polishing + applied glaze can be used to get best surface smoothness

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