

## Evaluating the effect of different combination of impression and pouring materials on marginal and internal adaptation of zirconia crowns.

Evaluación del efecto de diferentes combinaciones de materiales de impresión y vertido en la adaptación marginal e interna de las coronas de circonio.

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**Abstract: Purpose:** Two important factors in dental prosthesis are making an accurate impression and producing a suitable cast which represents the exact relationship between prepared tooth and oral structures. This study, aimed to investigate the effects of different combinations of impression and pouring materials on marginal and internal adaptation of premolar zirconia crowns. **Material and Methods:** Forty maxillary premolars were prepared considering round shoulder finish line. The impressions were made either by additional (Panasil) or condensation (Speedex) silicon, and poured by two different types of gypsum materials (Siladent or GC gypsum) (N=10). Zirconia crowns were fabricated using a CAD-CAM system. The crowns were cemented, and the samples were cut in bucco-lingual direction. Marginal and internal gaps were measured by stereomicroscope (×25). **Results:** The mean marginal gaps for Panasil-Siladent, Panasil-GC, Speedex-Siladent, and Speedex-GC were 141 μm, 143 μm, 131 μm, and 137 μm respectively. The internal gaps were 334 μm, 292 μm, 278 μm, and 257 μm respectively. The independent T-Student test showed no significant differences in average marginal or internal gap among various impression and gypsum materials or their interactions ( $p>0.05$ ). Two-way ANOVA test showed no significant differences in maximum marginal or internal gap among various impression and gypsum materials and their interactions ( $p>0.05$ ). **Conclusion:** The present study revealed no statistically significant difference in marginal/internal gap among crowns prepared using different combinations of impression-pouring materials evaluated.

**Keywords:** Dental restoration; Gypsum; Internal gap; Impression material; Marginal gap.

**Resumen: Introducción:** Dos factores importantes en la prótesis dental son hacer una impresión precisa y la producción de un modelo adecuado que represente la relación exacta entre el diente preparado y las estructuras orales. Este estudio, tuvo como objetivo investigar los efectos de diferentes combinaciones de materiales de impresión y vertido sobre la adaptación marginal e interna de coronas de circonio premolar. **Material y Métodos:** Se prepararon cuarenta premolares maxilares considerando la línea de meta del hombro redondo. Las impresiones se realizaron con silicio adicional (Panasil) o

de condensación (Speedex) y se vertieron con dos tipos diferentes de materiales de yeso (yeso Siladent o GC) (N = 10). Las coronas de zirconio se fabricaron utilizando el sistema CAD-CAM. Las coronas se cementaron y las muestras se cortaron en dirección buco-lingual. La brecha marginal e interna se midió con estereomicroscopio ( $\times 25$ ). **Resultados:** Las brechas marginales medias para Pansil-Siladent, Panasil-GC, Speedex-Siladent y Speedex-GC fueron de  $141\mu\text{m}$ ,  $143\mu\text{m}$ ,  $131\mu\text{m}$  y  $137\mu\text{m}$ , respectivamente. Las brechas internas fueron  $334\mu\text{m}$ ,  $292\mu\text{m}$ ,  $278\mu\text{m}$  y  $257\mu\text{m}$ , respectivamente. La prueba de T-Student independiente no mostró diferencias significativas en la brecha marginal

o interna promedio entre varios materiales de impresión y yeso o sus interacciones ( $p > 0.05$ ). La prueba ANOVA bidireccional no mostró diferencias significativas en el espacio marginal o interno máximo entre varios materiales de yeso y de impresión y sus interacciones ( $p > 0.05$ ). **Conclusión:** El presente estudio no reveló diferencias estadísticamente significativas en la brecha marginal/interna entre las coronas preparadas con diferentes combinaciones de materiales de impresión y vertido evaluados.

**Palabra Clave:** Restauración dental; Yeso; Brecha interna; Material de impresión; Brecha marginal.

## INTRODUCTION.

Although digital procedures changed many criteria in routine dental practices,<sup>1,2</sup> making an accurate oral impression and fabricating an accurate cast, still play important roles in accurate prosthesis fabrication.<sup>3</sup>

The poured impression should record the accurate details of the prepared tooth and the precise relation to surrounding structures. Nowadays, silicone elastomers (either condensation or addition) are among the most prevalent impression materials used for dental or implant impressions in a variety of situations.<sup>4</sup> However, the impression material is not the only factor that affects the recording of accurate details, another factor to consider is the pouring material. Different types of dental gypsums are available that can be classified based on ISO-6873<sup>5</sup> into five main types:

- type I- impression plaster,
- type II- pouring plaster,
- type III- pouring stone,
- type IV- high strength and low expansion die stone,
- type V- high strength and high expansion gypsum.

Type IV is the most prevalent type in pouring accurate cast and die.<sup>6</sup> The compatibility of pouring and impression materials, and the compensation potential of gypsum for dimensional changes of impression material, along with the porosity, strength, accuracy, and stability of pouring material are important factors on the final results.<sup>6,7</sup> There has been a continuing controversy in the literature about the impression and pouring materials compatibility (Table 1).<sup>8-13</sup>

The material compatibility could affect the accuracy and durability of the final end-result. Marginal and

internal adaptation of dental prosthesis are among the most important factors that affect long-term prosthesis success, and reflect the accuracy of the fabrication process.

Increased marginal discrepancy will increase the possibility of cement exposure to oral fluids, and that will enhance microleakage, cement solubility, recurrent caries, and periodontal problems.<sup>3-14</sup> Marginal adaptation is defined as the discrepancy between prepared finish-line and the restoration margin, and could be classified as vertical, horizontal, and absolute marginal gap, or over/under extension according to Holmes *et al.*,<sup>14</sup> The routinely investigated absolute gap is measured from the margin of restoration to the cavosurface angle of the prepared tooth finish line. The internal adaptation, on the other hand, affects the retention, resistance, and mechanical support of restorations.<sup>15,16</sup>

According to the lack of adequate research and controversial results on the role of applied material compatibility on the marginal and internal preciseness of zirconia crowns, it seems necessary to consider and investigate this subtle but important factor.

This study aimed to investigate the effect of four combinations of impression/pouring materials on the accuracy of final end-result: marginal and internal adaptation of zirconia crowns fabricated by computer assisted technology (CAD-CAM). The null hypotheses were that there are significant differences in marginal and also internal gaps of fabricated zirconia crowns between different combinations of impression/pouring materials.

## MATERIALS AND METHODS.

The study protocol was approved by the institutional ethics committee (IR.JSUMS.REC.1394-056); all patients gave their informed consent for use of the extracted teeth, and the study was performed considering the ethical standards of the revised Helsinki Declaration.

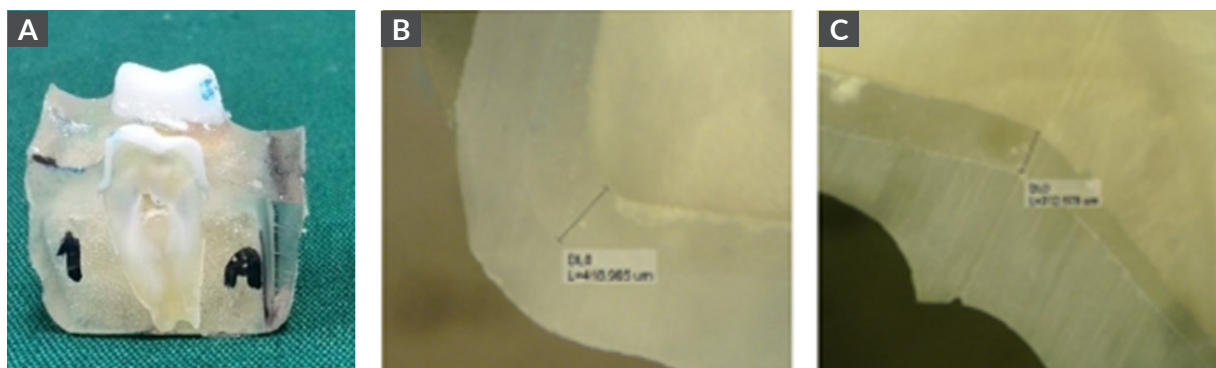
Forty maxillary premolar teeth were selected among intact, caries and restoration-free premolars extracted for orthodontic purposes. The teeth were kept in a sealed container in saline and diluted bleach for 24 hours. Afterwards, the teeth were inserted into acrylic blocks along their long axis.

Tooth preparation was made by diamond burs (Jota AG, Hirschsprungstrasse, Switzerland) considering 2mm occlusal reduction, 12 degrees of taper, and round shoulder finish-line with 1.5mm depth; the prepared surfaces were polished. All the preparations were performed by a prosthodontist. The teeth were randomly divided into two groups of 20 samples according to the

impression materials used for impression making. Twenty impressions were made by additional silicone (putty fast and extra light consistency, Polyvinylsiloxane, Panasil, Kettenbach GmbH & Co. KG, Eschenburg, Germany), and 20 by condensation silicone (Putty and light consistency, Condensation silicone, Speedex, Coltene/Whaledent co, Altstätten, Switzerland) using a two-stage method.

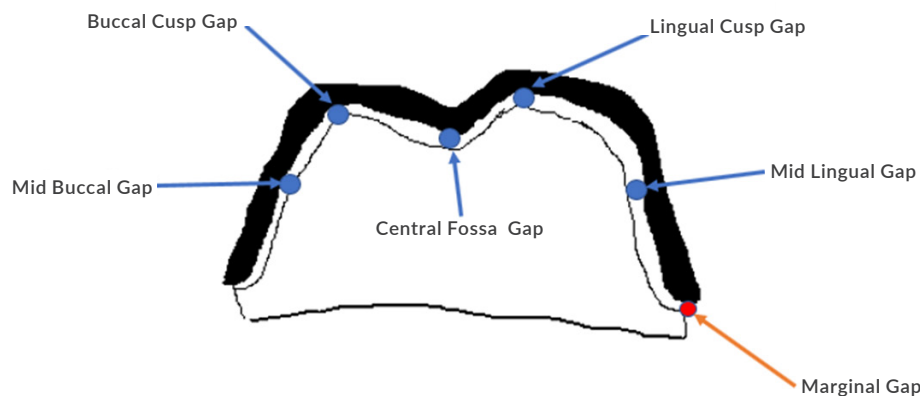
Each group was randomly divided to two subgroups (n=10) to be poured by two different type IV dental gypsums: Siladent gypsum (Marmoplast N, Dr. Böhme & Schöps GmbH, Goslar, Germany), or GC gypsum (GC Fujirock EP, GC America Inc, Patterson dental, Saint Paul, America) hour after impression making. The casts were scanned (D810 3shape Trios, Copenhagen, Denmark); pre-sintered high translucent zirconia crowns (DDcubeOne, Dental direkt GmbH, Spenge, Germany) were milled by milling machine (CORiTEC 350i, imes-core GmbH, Eiterfeld, Germany), and sintered in long program up to 1450o C for 16 hours according to

**Figure 1.** Absolute marginal adaptations by direct observation with a stereomicroscope (×25).



A: The samples were cross-sectioned bucco-lingually, ready to be directly evaluated under stereomicroscope. B: Stereo microscope photograph from cross-sectioned samples. C: Cement thickness measurements are provided in different zones.

**Figure 2.** Schematic drawing of different internal and marginal gaps measured in this study.



**Table 1.** Main results from studies evaluating impression and pouring materials compatibility.

Study	Impression materials used	Pouring materials used	Conclusion
Morrow <i>et al.</i> <sup>8</sup>	<b>Alginate:</b> Alginate Compound DP Elastic Compound Jeltrate Kalginate	<b>Gypsum:</b> DiKeen Glastone Stone True-Stone VelMix	Di-Keen was more compatible with impression materials than other stones. Jeltrate was more compatible with dental stones than other impression materials. The Di-Keen-Jeltrate combination was the most compatible combination, but not statistically better than DiKeen-DP, and VelMix-Jeltrate combinations.
Owen <i>et al.</i> <sup>9</sup>	<b>Alginate:</b> Blueprint Rapid Colourgel GC Fast-set Technicol GC Vericol Aroma Kalginate, fast-set err Alginate, fast-set S.S. White, normal set Zelgan Green, fast-set Zelgan Pink, normal-set	<b>Gypsum:</b> EPI Yellow stone (Kaffir D) Kerr Ortho stone Peaeh stone Plaster of Paris Vel-Mix (50:50 mixture of plaster of Paris and yellow stone)	Results obtained varied: Sometimes producing marked improvement Sometimes deterioration in surface quality of subsequent gypsum casts was identified
Butta <i>et al.</i> <sup>10</sup>	<b>Additional silicones:</b> Examix-NDS Doric-ES Flo-Light Panasil Contact Plus Extrude Wash President Plus Jet	<b>Type IV gypsum:</b> SilkyRock Fuji Rock Suprastone Vel-Mix	Different impression materials showed different compatibility with different Type IV gypsums: Super stone made 88% of completely reproduce casts
Chang <i>et al.</i> <sup>11</sup>	<b>Alginate:</b> Algiace Z Cavex Jeltrate <b>Silicone:</b> Aquasil LV Coltex fine Exaflex Regula Take1	<b>Gypsum:</b> MG crystal rock super hard stone MS plaster	Same accuracy More roughness in alginate than silicone Alginate cannot replace silicone rubber base
Vadapalli <i>et al.</i> <sup>12</sup>	<b>Polyvinyl-siloxane:</b> Impergum <b>Polyether:</b> aquasil	<b>Gypsum</b>	In dry conditions both materials performed almost equally In moist conditions Aquasil performed better than Impregum
Santini <i>et al.</i> <sup>13</sup>	<b>Addition silicone:</b> Exaflex Vinyl	<b>Type III Gypsum:</b> Heraeus Kulzer Moldadur Dental Stone <b>Type IV Gypsum:</b> Heraeus Kulzer Die Stone Peach	Type IV gypsum was more compatible with addition silicone than type III gypsum

manufacturer instructions. Cement space was set at 30 microns, started 1mm from the finish line. No adjustment was necessary for either of the groups, and sitting was confirmed by two independent expert observers for each crown.

Each crown was cemented on the tooth abutment by dual-cure resin cement (Panavia F2, Kuraray Noritake

dental Inc, Okayama, Japan). Twenty four hours later, each tooth-crown complex was sectioned using Mecatome (Mecatome T210, Presi GmbH, Angonnes, France) in the mid mesio-distal dimension on the line connecting buccal to palatal cusp tip. Absolute marginal and also internal adaptations were evaluated by direct observation under stereomicroscope (×25) (Figure 1).

**Table 2.** Descriptive information on marginal adaptation of evaluated groups (All the measurements are in µm).

Marginal gap	Panasil+Siladent		Panasil+GC		Speedex+Siladent		Speedex+GC	
	Buccal	Lingual	Buccal	Lingual	Buccal	Lingual	Buccal	Lingual
Mean (SD) µm	132.74 (58.61)	149.85 (63.31)	178.36 (82.21)	108.18 (54.74)	136.69 (54.19)	126.31 (44.46)	171.34 (45.43)	102.68 (45.42)
Max	230.99	247.08	293.86	222.22	233.99	187.13	236.84	197.37
Min	68.71	64.33	52.63	30.7	46.78	32.16	80.41	45.32

**Table 3.** Descriptive information on internal adaptation of evaluated groups (All the measurements are in µm)

Group	Internal gap	Mid Buccal- µm	Buccal Cusp- µm	Central Fossa- µm	Lingual Cusp- µm	Mid Lingual- µm
Panasil+ Siladent	Mean (SD)	128.06 (47.21)	568.21 (279.08)	298.34 (70.56)	581.70 (279.08)	94.29 (85.68)
	Max	513.16	1095.18	372.30	937.55	328.95
	Min	17.54	301.05	124.22	216.72	21.93
Panasil+ GC	Mean (SD)	75.58 (63.49)	455.55 (150.07)	342.02 (43.05)	452.25 (156.82)	139.47 (66.66)
	Max	236.84	672.44	431.45	678.95	232.46
	Min	30.70	188.80	301.16	168.73	57.02
Speedex+ Siladent	Mean (SD)	90.79 (45.19)	444.85 (114.67)	370.15 (133.27)	386.09 (183.62)	101.75 (37.54)
	Max	162.28	601.26	609.05	667.74	153.51
	Min	30.70	267.07	210.25	110.44	35.09
Speedex+ GC	Mean (SD)	80.26 (66.35)	431.53 (110.05)	340.38 (71.62)	353.56 (126.21)	79.38 (25.52)
	Max	201.75	614.97	426.10	599.23	118.42
	Min	13.16	321.09	225.85	209.28	43.86

**Table 4.** Internal and marginal gaps in different combination of impression materials and pouring stone (All the measurements are in µm)

Index	Impression	Gypsum	Minimum	Maximum	Mean	Std. Deviation
Marginal gap (µm)	Panasil	Siladent	66.52	190.79	141.30	44.18
		GC	63.60	220.03	143.27	48.93
	Speedex	Siladent	99.42	165.94	131.50	24.21
		GC	84.07	182.75	137.01	30.93
Internal gap (µm)	Panasil	Siladent	198.33	533.68	334.12	107.76
		GC	166.80	371.14	292.98	63.30
	Speedex	Siladent	156.47	378.83	279.12	77.68
		GC	180.60	356.82	257.02	56.96

Marginal measurements were made three times in buccal and lingual finish lines for each sample, and the mean quantity was reported as a marginal gap in each side. For internal adaptation, five measurements were made for each sample in mid-buccal, mid-lingual, buccal and lingual cusp tips, and central fossa (Figure 2).

The results were analyzed using two-way ANOVA, and independent T-test.

## RESULTS.

Table 2 and Table 3 summarize descriptive analyses for marginal and internal gaps respectively; Table 4 presents the effect of different combinations of impression and pouring materials on marginal and internal gaps.

The results confirmed that neither the impression material type ( $p=0.512$ ), nor the gypsum type ( $p=0.760$ ) had a significant effect on marginal adaptation of zirconia crowns, and the interaction between impression material and gypsum type also had no significant effect on marginal adaptation ( $p=0.885$ ).

Internal adaptation showed the same pattern of results; neither the impression material type ( $p=0.077$ ), nor the gypsum type ( $p=0.213$ ) had significant effect on internal adaptation of zirconia crowns, and the influence of interaction between impression material and gypsum type was not significant ( $p=0.705$ ).

The statistical analyses of maximum measurements by two-way ANOVA showed that maximum quantity of marginal gap of different groups was not affected significantly by impression materials ( $p=0.342$ ), or gypsum types ( $p=0.338$ ).

The impression material ( $p=0.080$ ), or type of pouring material ( $p=0.051$ ) also had no significant effects on maximum internal adaptations. Even the interaction between these two varieties caused no significant change in maximum marginal ( $p=0.742$ ), or maximum internal ( $p=0.161$ ) adaptation of zirconia crowns.

## DISCUSSION.

Different factors affect success and longevity of restorative treatments; among them, the adaptation of prosthesis may play a special role. Marginal adaptation is the decisive factor in probability of occurrence of caries and periodontal problems. Internal adaptation, on the other hand, determines stability and retention of

the prosthesis<sup>15-17</sup> that might be even more important in special situations of short abutment, or higher bite forces. The fabrication steps are critical factors in the accuracy of laboratory made restorations.<sup>18</sup>

Wide range of routinely used impressions and pouring materials, and their interactions are among pivotal issues to be considered.<sup>19</sup> Elastomeric impression materials are the most prevalent materials used in every-day prosthetic practices. Condensation and additional silicones are still applied frequently despite significant improvements in digital dentistry.<sup>20</sup> After impression making, the impression might be poured in the lab to have a precise model for restoration fabrication. Any incompatibilities or negative interactions between impression and pouring materials could negatively affect the result and cause inaccuracy in fabricated product<sup>21</sup> despite all the efforts made in the fabrication steps. The materials tested in the present research (condensation or additional silicone as impression materials and two types of pouring gypsums) are among the most prevalent materials used in prosthetic practices; however, their interactions caused no significant difference in restorations' marginal and internal adaptations, and the null hypothesis was rejected.

The clinically acceptable marginal gap is considered 120 $\mu$ m according to McLean *et al.*,<sup>22</sup> and less than 150 $\mu$ m according to Jemt *et al.*,<sup>23</sup> Different studies have reported the marginal gap of 10 to 160 $\mu$ m in CAD-CAM milled zirconia copings,<sup>24-26</sup> and 11 to 58 $\mu$ m in full zirconia restorations.<sup>27-29</sup> The marginal adaptations in the present study were not in a clinically acceptable range according to Mclean criteria except for lingual surface of either impression material poured by GC gypsum. However, according to the Jemt criteria, all the marginal gaps were clinically acceptable except for the buccal margins of either impression materials poured by GC gypsum. This result is not confirmed by other studies that evaluated marginal gap in zirconia crowns;<sup>24-27,30,31</sup> however, the role of conventional impression making and cast pouring may significantly change the *in-vitro* results obtained, as well as the method of gap measurement,<sup>29</sup> the cement space, the fabrication system accuracy, and the preparation design,<sup>26,27</sup> as well as the sintering technique.<sup>25,26</sup> Generally, the accuracy of milling in lingual finish line was more than buccal side. The difference between the milled material thickness and volume could justify this finding; since, thicker material could more successfully compensate for milling subtle inaccuracy.

Application of direct preparation scanning or impression scanning might provide completely different results. There is no consensus on the clinically acceptable internal gap. However, the internal gap should provide a uniform and adequate cement space, while not compromising retention and resistance.<sup>31</sup> In the groups evaluated in the present study, the internal gaps were generally higher for occlusal surfaces (buccal/lingual cusp tips, and central fossa). The increased occlusal gap compared to other surfaces has been reported by several studies irrespective of the fabrication method employed.<sup>32-35</sup>

This result could be attributed to the more complex occlusal anatomic design, the possibility of more interferences in the occlusal surface according to computer milling mechanism, or intensified effects of axial/marginal interferences in occlusal section of the restoration.<sup>32,33</sup> When it comes to conventional impression and cast pouring, all these factors might play a more relevant role, since the dimensional changes of conventional materials will affect the restoration adaptation.

Considering the axial surfaces, all the internal measurements were under the 120µm described by McLean *et al.*,<sup>22</sup> except the mid buccal values in Panasil+Siladent, and midlingual measurements in the Panasil+GC groups; both made by additional silicone impression. This could be covered by more dimensional stability of additional silicone<sup>36,37</sup> that prevent material expansion outward from the tooth mold and results in smaller die compared to what is made by condensation silicone impression. Although each coping was milled after the scanning of related die, but, the die size might affect the milling accuracy considering the milling bur size and scanning limitations.

The result emphasizes the importance of creating space for low-consistency additional silicone wash covering the high-consistency material, and providing a thicker die spacer for the die poured from additional silicone impressions, compared to those poured from condensation silicone.

The wide range of standard deviations could be explained by finger pressure used for crown cementation. Although tried to be uniform and applying even pressure, the possibility of incorrect insertion or uneven pressure possibly due to the lack of opposite and adjacent teeth as insertion guides could not be ruled out. The same wide range was also shown in the Coli *et al.*,<sup>38</sup> and Kokubo *et al.*,<sup>34</sup> studies.<sup>35</sup> This result emphasizes the importance of attention to the insertion

accuracy in clinical practice.

However, the purpose of this study was to evaluate the effect of material interaction on marginal/internal adaptation that was shown to be statistically non-significant.

There are other factors that potentially influence restorations' marginal/internal adaptation, namely tooth preparation design, cement type, restoration fabrication procedure, position and number of points evaluated, and the measurement method employed.<sup>30</sup> The present study evaluated natural teeth and used milled zirconia crowns to imitate a clinical situation, however, the adaptation measurements were made only in two aspects. Further studies considering other combinations of materials, other measurement methods, and evaluating the materials interaction effects in full arch restorations are suggested.

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