

# Effect of disinfection of irreversible hydrocolloid impression materials with 1% sodium hypochlorite on surface roughness and dimensional accuracy of dental stone casts

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## ABSTRACT

**Aim:** The aim of this study was to evaluate the effect of disinfection of commercially available irreversible hydrocolloid impression materials with 1% sodium hypochlorite on the surface roughness and dimensional accuracy of dies produced using type IV dental stone. **Materials and Methods:** Four different brands of irreversible hydrocolloid impression materials were used as follows: Jeltrate Plus without disinfection (GJ), Jeltrate Plus with disinfection (GJD), Hidrogum without disinfection (GH), Hidrogum with disinfection (GHD), Hidrogum 5 Days without disinfection (GH5), Hidrogum 5 Days with disinfection (GH5D), Cavex without disinfection (GC), and Cavex with disinfection (GCD). A total of 80 dies were poured using type IV dental stone and their mean surface roughness was evaluated using rugosimeter (Mitutoyo SJ-400). To conduct the dimensional alteration analysis, type IV dental stone casts were obtained from a matrix made of chemically-activated resin. They were analyzed in a coordinate-measuring machine (Brown and Sharpe). **Statistics Analysis:** Numerical data were analyzed using analysis of variance (ANOVA) with Tukey's *post hoc* test at 5% confidence interval. **Results:** Hidrogum 5 Days and Cavex showed the least surface roughness value even after 5 days. There were no significant differences in the dimensional alteration of Jeltrate (GJ and GJD) and Hidrogum (GH and GHD) in relation to the "new brands" Hidrogum 5 (GH5 and GH5D) and Cavex (GC and GCD), even after 5 days of storage. **Conclusion:** Considering the results obtained, it can be concluded that there was a roughness increase in the die stones poured from irreversible hydrocolloids disinfected with sodium hypochlorite.

## Key words

Dental stone, dimensional alteration, irreversible hydrocolloid, surface roughness

## INTRODUCTION

Irreversible hydrocolloids have been used in dentistry as an impression material for a long time. This material can be used for obtaining both study and working casts in removable partial dentures (RPDs) for example.

The good acceptance of irreversible hydrocolloid impression material is because of its easy handling, low cost, capability of reproducing details, and high comfort

for the patient.<sup>[1,2]</sup> Notwithstanding, its main disadvantage is the volumetric change of the impression after removal from the mouth. Consequently, the dental stone must be poured immediately.<sup>[3,4]</sup> Another disadvantage is its lack of adhesion to the tray resulting in possible distortion of the impression during its removal from patients oral cavity.<sup>[4]</sup>

Currently, the dental market has launched siliconized, irreversible hydrocolloids, which according to the manufacturers, have an increased dimensional stability so that the impression can be poured up to 5 days without damaging the cast quality.

Wandrekar *et al.*, demonstrated that most of the so-called 5-day stable irreversible hydrocolloid really showed good dimensional stability during this period and an acceptable stability during a 7-day period when stored at 100% humidity.<sup>[5]</sup>

Due to the increasing number of cases of people infected

Access this article online	
Quick Response Code:	Website: www.ejgd.org
	DOI: 10.4103/2278-9626.134835

with diseases such as hepatitis, herpes, acquired immunodeficiency syndrome, tuberculosis, pneumonia, or even a common flu. As well as the fact that there is an increase in the transmission of infectious diseases among health professionals (doctors, dentists, and nurses), more effective attitudes towards the control of the contamination in dental offices and laboratories are mandatory.<sup>[6]</sup> The American Dental Association (ADA) and the Health Department of the state of São Paulo/Brazil have recommended the disinfection of dental impressions because they are exposed to saliva and blood which could lead to cross-contamination that must be avoided and controlled.

The current protocol for hydrocolloid disinfection recommended by the Centers for Disease Control and Prevention is the use of homemade bleach (1:10 dilution), iodoform, synthetic phenols, or glutaraldehyde by immersion or spray. First, the impression should be washed under running water and a disinfection solution sprayed on it. Immediately after, the impression must be wrapped in paper towel, moistened with disinfection solution, and sealed with a plastic bag for 10 min. Last, the paper towel is removed and the impression washed, dried and poured with the dental stone of choice. An alternative method of disinfection is immersion; however, this cannot surpass 10 min.<sup>[1]</sup>

Oliveira and Jóias evaluated the dimensional alteration of irreversible hydrocolloid impressions and concluded that the disinfection with 0.5% sodium hypochlorite spray for 10 min did not influence their dimensional stability.<sup>[7]</sup> Pavarina *et al.*, investigated the influence of the impression disinfection on the dimensional alterations of dental casts. Irreversible hydrocolloid showed a significant dimensional alteration, in two of the five areas analyzed.<sup>[8]</sup> The authors also concluded that washing in water, immersion in 2% glutaraldehyde solution and in 0.5% sodium hypochlorite solution did not lead to dimensional alteration in the dental casts. Therefore, the authors recommended that the irreversible hydrocolloid impressions can be disinfected with 0.5% sodium hypochlorite solution for 30 min, without causing significant dimensional alterations in the dental casts.

The characteristics of type IV dental stone include high abrasion resistance. With Rockwell hardness of about 92 MPa and minimum setting expansion it has been largely used for obtaining working casts in restorative dentistry. Additionally, it is relatively inexpensive, is easy to manipulate, generally compatible with many impression materials.<sup>[9]</sup> However, to assure that type IV dental stone maintains its favorable features, caution must be taken as recommended by manufacturer's instructions. The Vickers hardness of type IV dental stone decreases when the minimum period of 30 min of setting is not respected; also, the water/powder ratio and the proper handling of the dental stone must be observed.

The determination of the compatibility between the dental stone and the impression material is also a valid aim in obtaining an ideal cast.<sup>[10,11]</sup>

These factors are extremely important since many RPDs have been constructed onto working casts obtained from irreversible hydrocolloid impressions. Thus, the copy properties of the impression material associated with good quality of dental stone reproduction help obtain more reliable casts, which reproduce in a morpho-dimensional way the structures without superficial alterations, enabling both the dentist and the prosthetic technician to execute the cases successfully. One should also consider the biosecurity factor aiming the health of all people involved in the case.

Considering this information, the aim of this study was to evaluate the interaction of type IV dental stone with irreversible hydrocolloids of different brands subjected to disinfection with 1% sodium hypochlorite through assessment of mean roughness and dimensional alteration.

## MATERIALS AND METHODS

### Surface roughness

To construct the specimens for the superficial roughness test, two aluminum matrices (145 mm × 105 mm) were used with one of them having 25 perforations (15 mm of diameter and 3 mm of height). The other matrix was smooth, without perforations, and was used as a support device for obtaining the samples. Also, a polished glass plate was employed to reach a smooth and ideal surface of the alginate [Figure 1].

Four different commercial brands of irreversible hydrocolloid were used: Jeltrate Plus (Dentsply), Hidrogum (Zhermack), Hidrogum 5 Days (Zhermack), and Cavex (Cavex Holland) and two different brands of type IV dental stone were employed: Durone (Dentsply) and Elite Rock (Zhermack). Each group comprised 10 samples as follows:

- GROUP J: Jeltrate Plus and Durone without

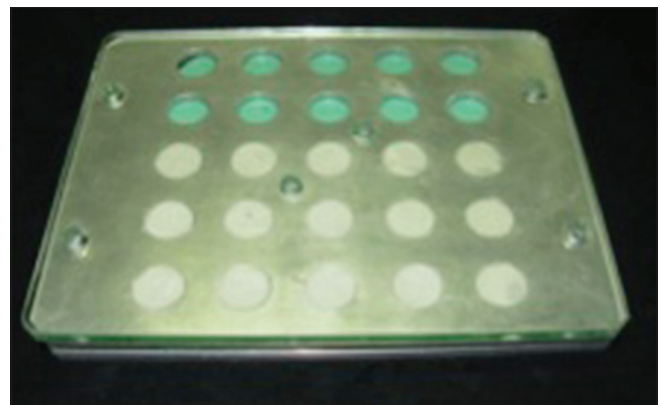


Figure 1: Type IV dental stone poured to the perforations

disinfection

- GROUP JD: Jeltrate Plus and Durone with disinfection
- GROUP H: Hidrogum and Elite Rock without disinfection
- GROUP HD: Hidrogum and Elite Rock with disinfection
- GROUP H5: Hidrogum 5 Days and Elite Rock without disinfection
- GROUP H5D: Hidrogum 5 Days and Elite Rock with disinfection
- GROUP C: Cavex and Elite Rock without disinfection
- GROUP CD: Cavex and Elite Rock with disinfection.

Each impression material was mixed according to the proportion indicated by the manufacturer. After setting, the disinfection was executed according to the group selected. This was carried out through spraying 1% sodium hypochlorite followed by storage for 10 min at 100% environmental humidity. Next, the irreversible hydrocolloid was washed under running water and dried with paper towel. Then, the perforated plate was placed onto the alginate layer to pour the dental stone.

In the groups of Jeltrate and Hidrogum, the dental stone was poured just after disinfection, while in groups Hidrogum 5 and Cavex, the irreversible hydrocolloid was stored for 5 days at 100% environmental humidity. A 100% humidity was maintained by using a plastic tupperware with a sponge soaked in water, the sponge was soaked every 24 h until the 5 days of storage was completed. After that the dental stone was poured.

Type IV dental stone was mixed according to the proportion recommended by the manufacturer and poured into the perforations of the matrix so that the plate was kept onto a dental stone vibrator during this procedure. After the material setting, the dental stone pastilles were removed from the device and subjected to the mean roughness analysis [Figure 2].



Figure 2: Dental stone samples

The roughness of the samples was evaluated using a rugosimeter (Mitutoyo SJ-400). Three readings were made for each sample so that the mean surface roughness (Ra) ( $\mu\text{m}$ ) was calculated. Ra is the arithmetic mean of all deviations of the roughness profile from the mean line within the measuring length. It provides an overall panorama of the sample roughness.

The numerical data were submitted to statistical analysis through analysis of variance and Tukey's test with level of significance of 5%.

### Dimensional alteration

A chemically-activated acrylic resin master mold was used to conduct the dimensional alteration test mimicking an edentulous maxillary arch. On the ridge, four spheres were fixed at the right tuberosity (1), left tuberosity (2), anterior area (3), and the middle of the palate (4) [Figure 3].

Eighty impressions of the master mold were executed with three parts of irreversible hydrocolloid and with the aid of a size 3 stock tray (Tecnodent Ind. e Com., São Paulo - SP).

After setting, the impression was carefully removed and was treated mimicking a clinical condition: Washing in running water and drying with paper towel.

The 80 impressions of each irreversible hydrocolloid were divided into eight groups with 10 impressions each according to the experimental conditions: Type of irreversible hydrocolloid and dental stone; with or without disinfection.

The dental stones samples were obtained by mixing 100 g of stone and 19 ml of water, according to the manufacturer's instructions.

With the aid of a coordinate-measuring machine (Brown and Sharpe), the reading of the acrylic resin master mold



Figure 3: Chemically-activated acrylic resin master mold

was performed. This machine locates the center of each sphere and calculates automatically through its software, the line segment at the space corresponding to the distance between the centers. Next, the measurements of the dental stone samples were carried out, thus obtaining the values to be compared with the master mold. The measurements were executed 24 h after the pouring of the impressions.

The data obtained were submitted to descriptive and inferential statistical analysis through analysis of variance (ANOVA) and Tukey's tests with level of significance of 5%.

## RESULTS

The measure of central tendency (mean) of the values' distribution and the dispersion (standard deviation) of the two independent variables were studied: Roughness and dimensional alteration are seen in Tables 1-3.

After the normality tests, two-way ANOVA at 5% was applied. Next, Tukey's test was applied in the groups that are statistically different (5%).

The results of the inferential statistics of the roughness are displayed in Table 4.

Regarding the dimensional alteration, because the analyses were performed for each distance on the samples, Table 5 shows the percentage of alteration between the measurements of the samples analyzed in relation to the master mold.

By taking into consideration that all impressions should be disinfected, a statistical analysis was executed only with data obtained from the impressions undergoing disinfection. The result of the analysis of variance detected significant statistical difference only between segments 03 and 04 according to Tables 6 and 7.

## DISCUSSION

This study evaluated the superficial roughness and dimensional alteration of type IV dental stone obtained from impressions of four different brands of irreversible hydrocolloid with disinfection by spraying 1% sodium hypochlorite.

Popular commercial brands (Jeltrate and Hidrogum) were compared to Hidrogum 5 Days and Cavex, as newer extended pour time materials.

During the impression making with irreversible hydrocolloid, the microorganisms of the patient's mouth are transferred to the impressions. Such fact becomes a medium for possible contamination of both the dentists and assistants at the office. The use of universal procedures and precautions in dental offices

**Table 1: Mean (± standard deviation) of the roughness data (µm) obtained in the study**

Disinfection	Impression material				Line (mean±sd)
	J	H	H5	C	
With	4.90±0.52	1.94±0.25	0.82±0.21	1.26±0.12	2.23±1.64
Without	6.23±1.69	4.89±1.21	2.01±0.73	1.89±0.47	3.76±2.18
Column (mean±sd)	5.57±1.39	3.41±1.73	1.41±0.90	1.57±0.47	

J – Jeltrate plus; H – Hidrogum; H5 – Hidrogum 5 days; C – Cavex; sd – Standard deviation

**Table 2: Mean (± standard deviation) of the dimensional alteration data (mm) obtained in the study**

Material	Disinfection	01-02	02-03	01-03
J	With	42.68±0.04	44.64±0.04	44.36±0.04
J	Without	42.68±0.04	44.66±0.06	44.34±0.05
H	With	42.71±0.01	44.65±0.01	44.34±0.03
H	Without	42.68±0.02	44.65±0.02	44.36±0.06
C	With	42.72±0.06	44.64±0.06	44.22±0.15
C	Without	42.68±0.03	44.64±0.02	44.31±0.07
H5	With	42.70±0.05	44.66±0.07	44.29±0.20
H5	Without	42.71±0.04	44.65±0.03	44.34±0.07
Master mold		42.65	44.62	44.39

J – Jeltrate plus; H – Hidrogum; H5 – Hidrogum 5 days; C – Cavex

**Table 3: Mean (± standard deviation) of the dimensional alteration data (mm) obtained in the study**

Material	Disinfection	01-04	02-04	03-04
J	With	27.31±0.04	28.61±0.03	26.92±0.05
J	Without	27.30±0.05	28.60±0.05	26.91±0.07
H	With	27.33±0.02	28.64±0.01	26.90±0.04
H	Without	27.31±0.03	28.62±0.03	26.94±0.04
C	With	27.37±0.20	28.71±0.10	26.79±0.10
C	Without	27.29±0.08	28.64±0.03	26.88±0.08
H5	With	27.23±0.15	28.70±0.07	26.86±0.15
H5	Without	27.31±0.08	28.64±0.07	26.94±0.11
Master mold		27.29	28.55	26.97

J – Jeltrate plus; H – Hidrogum; H5 – Hidrogum 5 days; C – Cavex

**Table 4: Result of the test of multiple comparisons of the means**

MI	Disinfection	Mean (µm)	Mean (1+log) (µm)	Homogenous groups*
J	with	6.23	0.84	A
J	without	4.90	0.77	A
H	with	4.89	0.76	A
H	without	1.94	0.46	B
H5	with	2.01	0.46	B
H5	without	0.82	0.25	D
C	with	1.89	0.45	B C
C	without	1.26	0.35	C D

Formation of groups of same behavior after Tukey's test (5%). Means followed by the same letter are not statistically different. J – Jeltrate plus; H – Hidrogum; H5 – Hidrogum 5 days; C – Cavex



**Table 5: Table of % of distortion in relation to the measurement of the master mold**

Material	Disinfection	01-02 (%)	02-03 (%)	01-03 (%)	01-04 (%)	02-04 (%)	03-04 (%)
J	With	0.09	0.06	0.05	0.11	0.24	0.18
J	Without	0.08	0.09	0.11	0.06	0.18	0.22
H	With	0.15	0.08	0.10	0.18	0.34	0.23
H	Without	0.09	0.08	0.05	0.07	0.26	0.10
C	With	0.18	0.05	0.37	0.29	0.58	0.65
C	Without	0.09	0.06	0.17	0.01	0.33	0.33
H5	With	0.12	0.11	0.22	0.22	0.55	0.40
H5	Without	0.14	0.08	0.10	0.09	0.32	0.10

J – Jeltrate plus; H – Hidrogum; H5 – Hidrogum 5 days; C – Cavex

**Table 6: Analysis of variance for the distance between points 03 and 04**

	SS	DF	MS	F	P value
Intercept	28882.62	1	28882.62	2846883	0
M	0.1	3	0.03	3	0.035935
Error	0.37	36	0.01		

SS – Sum of squares; DF – Degrees of freedom; MS – Mean square; M – Mean

**Table 7: Result of the multiple comparison test of the means**

M 03-04	Homogenous groups
C	A
H5	A B
H	A B
J	B

Formation of groups of same behavior after Tukey's test (5%). J – Jeltrate plus; H – Hidrogum; H5 – Hidrogum 5 days; C – Cavex

and laboratories have prevented the cross-contamination among dentists, technicians, and patients.<sup>[12]</sup> Common practices include disinfection of impressions with either 0.5% or 1% sodium hypochlorite and 2% glutaraldehyde solutions by immersion, friction, or spraying.<sup>[13]</sup>

Because sodium hypochlorite is a disinfection solution of low cost and toxicity, with effectiveness against a broad spectrum of microorganisms including human immunodeficiency virus, hepatitis B as well as numerous other bacteria, it is commonly employed by many dentists and hence was chosen for this study.<sup>[14]</sup> In the literature review study conducted by Gonçalves *et al.*, it was demonstrated that the alterations in the casts from the impressions submitted to sodium hypochlorite can be considered irrelevant in most of the cases in relation to careless uses of impression material and techniques and to the risk of contamination that may occur.<sup>[15]</sup>

Johnson *et al.*, reports that the immersion of irreversible hydrocolloid impressions in sodium hypochlorite results in a more effective disinfection than when those were sprayed.<sup>[16]</sup> On the other hand, Tan *et al.*, stated that the

disinfection by sodium hypochlorite immersion caused dimensional alteration so that the spray is the most indicated.<sup>[17]</sup>

Because of concerns regarding dimensional alteration after the disinfection of irreversible hydrocolloid impressions by immersion or spraying, Zanet *et al.*, showed that 1% sodium hypochlorite did not result in significant dimensional alterations.<sup>[18]</sup> However, other studies showed that the immersion in disinfection solution could cause certain alteration of the dimensional stability. In a study of Júnior *et al.*, there was a decrease of the area (in mm<sup>2</sup>) of the type IV dental stone samples, which resulted in relevant misadaptation of prostheses waxed onto these casts.<sup>[19]</sup> However, there was no increase in superficial porosity without statistically significant differences in the superficial roughness values before and after disinfection. Another study showed a statistically significant effect on the dimensional stability when immersed in hypochlorite solution. However, this was not considered to be clinically significant.<sup>[11]</sup>

In the present study, it was noted that the disinfection of irreversible hydrocolloid impression material by spraying of 1% sodium hypochlorite resulted in significant superficial alteration of roughness in the dental cast obtained with two brands—Hidrogum and Hidrogum 5. On the other hand, in the groups Jeltrate and Cavex there was no significant difference due to the disinfection. By comparing the different irreversible hydrocolloid brands, Hidrogum 5 and Cavex showed the best superficial roughness values and they were statistically different from Jeltrate and Hidrogum, an observation that can be possibly justified by the composition of these new irreversible hydrocolloid types which provide a smoother surface. An adequate type IV dental stone casts should present texture values between 1.0 and 1.5 µm.<sup>[20]</sup> By analyzing the results, it was verified that only the groups of Hidrogum 5 and Cavex without disinfection were within these values. Therefore, it can be said that the disinfection compromised the cast in relation to the roughness. In the groups of Jeltrate and Hidrogum, the values of the samples either undergoing disinfection or not were higher than those considered as adequate, suggesting that disinfection was not a major problem rather than the interaction between the irreversible hydrocolloid and dental stone which somehow compromised the cast leading to this higher superficial roughness. This is in agreement with the results of another study that clearly showed that spray disinfection did have an effect on the reproduction of the details in an irreversible hydrocolloid. However, when the irreversible hydrocolloid control was compared to the disinfected irreversible hydrocolloid group, no differences were noted, concluding that disinfection was not found to have any effect on the irreversible hydrocolloid.<sup>[21]</sup> Rentzia *et al.*, also verified an increase in Ra values after immersion of irreversible hydrocolloid in hypochlorite solution, but for the authors

it is unclear whether the increased Ra values observed would have a clinically significant effect on the surface quality of the casts.<sup>[11]</sup>

Amalan *et al.*, showed that the hypochlorite promotes alterations on the surface of the impression materials; sodium hypochlorite reduced the detail reproduction in irreversible hydrocolloids that could be attributed to the accelerated setting preventing it from flowing into the details.<sup>[22]</sup>

In the dimensional alteration analysis, six distances were evaluated among the four spheres positioned on the master mold. The results showed statistically significant differences in the comparison among irreversible hydrocolloid, but only in three of these distances. Jeltrate and Hidrogun had a better performance than the “new” Hidrogun 5 and Cavex. However, it has to be considered that these casts were only obtained after 5 days of storage. The same fact was seen in the results of Wadhwa *et al.*, which indicated that all the irreversible hydrocolloid exhibited a continuous decrease in distance with delay in pouring.<sup>[23]</sup> These observed changes showed that immediate pouring produced the most accurate casts for all the materials studied.<sup>[23]</sup> Accordingly, water evaporation may have occurred during the storage, which in addition to the powder/water mixing may have caused this dimensional alteration. On the other hand, this alteration is not considered as significant because it only occurred in some of the measurements analyzed and they were below the standard percentage stated by International Organization for Standardization (ISO) guideline for elastomeric impression materials: 1.5%. This is in agreement with other studies.<sup>[23,24]</sup> By verifying the Table 5, the dimensional alteration differences (%) in relation to the measurements of the master mold could be seen, not surpassing 1.5%.

Concerning disinfection of the impressions, it was verified that the dimensional alteration occurred in all segments, but statistically significant differences were observed only in two of the six measurements (segment 02-04 and 03-04). However, these alterations were still below the 1.5% stated by ISO guideline as clinically acceptable, corroborating other studies that demonstrated significant alterations after disinfection.<sup>[15,18,19,21]</sup>

Within the limits of this study, it can be concluded that regarding roughness, the disinfection of the impressions with 1% sodium hypochlorite showed statistically significant differences in groups Hidrogun and Hidrogun 5. The roughness of all irreversible hydrocolloids tested reached values above those clinically acceptable, except for group Cavex and Hidrogun 5 without disinfection. These high roughness values could have been influenced by the interaction between the alginate with the dental stone rather than the disinfection of the impressions.

The dimensional alteration occurred in all segments, but statistical differences were only found in three of the six segments measured. This alteration was below 1.5% stated by ISO guideline as clinically acceptable. Therefore, it can be concluded that neither the disinfection of the impressions nor the 5 day storage recommended by the manufacturers of Hidrogun 5 and Cavex caused a dimensional alteration capable of compromising the clinical viability of the cast. As the results from Wadhwa *et al.*, we can also suggest that all the impression materials tested in this study, when stored properly, were dimensionally stable enough for fabrication of master casts for RPDs.<sup>[23]</sup>

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**How to cite this article:** Dorner AR, Ferraz da Silva JM, Uemura ES, Borges AL, Fernandes Junior VB, Yamamoto EC. Effect of disinfection of irreversible hydrocolloid impression materials with 1% sodium hypochlorite on surface roughness and dimensional accuracy of dental stone casts. *Eur J Gen Dent* 2014;3:113-9.

**Source of Support:** Nil, **Conflict of Interest:** None declared.

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- If any of the bibliographic elements are missing, incorrect or extra (such as issue number), it will be shown as INCORRECT and link to possible articles in PubMed will be given.