# Effect of Storage Time on Tear Strength of Extended-Pour Irreversible Hydrocolloid Impression Materials

# Saklama Süresinin Uzatılmış Model Elde Etme Süresine Sahip İrreversible Hidrokolloid Ölçü Malzemelerinin Yırtılma Dayanımı Üzerine Etkisi

**Volkan Şahin[1], Hossein Jodati[2], Zafer Evis[3]**

[1]Department of Prosthodontics, Faculty of Dentistry, Kirikkale University, Kirikkale, Turkey.

[2]Biomedical Engineering Department, Middle East Technical University, Ankara, Turkey.

[3]Sciences Department, Middle East Technical University, Ankara, Turkey.

## Abstract

**Objective:** The aim of this in vitro study was to evaluate the effect of prolonged storage times on the tear strength of extended-pour irreversible hydrocolloid impression materials.

**Material-Method:** Eighty four specimens were fabricated from five commercial extended-pour irreversible hydrocolloid impression materials (BluePrint Xcreme, Hydrogum 5, Kromopan, Alginmax and Alginelle) as well as one experimental formula in accordance with the ISO 21563:2013 standard effective for irreversible hydrocolloid impression materials. Specimens were randomly divided in two groups for each impression material (n=7) and subjected to tear strength test immediately (base line) or after 120 hours of storage. Tear strength values were obtained in N/mm and data were analysed with two-way ANOVA (irreversible hydrocolloid brand, storage time). Multiple comparisons were performed with Tukey's test (p=0.05).

**Results:** The tear strength of the extended-pour irreversible hydrocolloid impression materials were affected by brand ($p<0.0001$) and brand-storage time interaction ($p=0.005$). Storage time did not influence the tear strengths of the extended-pour irreversible hydrocolloid impression materials tested except Alginmax whose mean tear strengths increased after 120 hours of storage ($p<0.05$). At base line measurements Blueprint Xcreme provided the highest mean tear strength values (1.08±0.19 N/mm) whereas Alginelle provided the lowest mean tear strength values (0.51±0.3 N/mm). Hydrogum 5 provided the highest tear strength values after 120 hours of storage (1.15± 0.12 N/mm) whereas Alginelle provided the lowest mean tear strength values (0.55±0.04 N/mm).

**Conclusions:** All commercial extended-pour irreversible hydrocolloid impression materials tested maintained their tear strengths after 120 hours of storage.

**Keywords:** Tear Strength, Irreversible Hydrocolloid, Impression Material, Storage

## Özet

**Amaç:** Bu in-vitro çalışmanın amacı; uzatılmış saklama sürelerinin, uzatılmış model elde etme süresine sahip irreversible hidrokolloid ölçü malzemelerinin yırtılma dayanımı üzerine etkisini incelemektir.

**Materyal-Metot:** Beş ticari (BluePrint Xcreme, Hydrogum 5, Kromopan, Alginmax ve Alginelle) ve bir özel formüle edilmiş uzatılmış model etme süresine sahip irreversible hidrokolloid ölçü malzemesi kullanılarak ISO 21563:2013 standartlarına uyumlu seksen dört adet numune hazırlanmıştır. Her bir ölçü malzemesine sait numuneler rastgele iki gruba ayrılmış (n=7) ve hemen veya 120 saatlik saklama süresi sonunda yırtılma testine tabi tutulmuşlardır. Yırtılma dayanımı değerleri N/mm cinsinden ifade edilmiş ve veriler iki yönlü varyans analizi testi (irreversible hidrokolloid markası, saklama süresi) kullanılarak analiz edilmiştir. Çoklu karşılaştırmalara, Tukey testi kullanılarak yapılmıştır ($p=0.05$).

**Bulgular:** Uzatılmış model etme süresine sahip irreversible hidrokolloid ölçü malzemelerinin yırtılma dayanımları, irreversible hidrokolloid markası parametresi ($p<0.0001$) ve irreversible hidrokolloid markası-saklama süresi etkileşimi tarafından etkilenmiştir ($p=0.005$). tarafından etkilenmiştir Saklama süresi, uzatılmış model etme süresine sahip irreversible hidrokolloid ölçü malzemelerinin yırtılma dayanımlarını, 120 saat saklama süresi sonunda yırtılma dayanımı artan Alginmax ölçü malzemesi haricinde etkilememiştir ($p<0.05$). Hemen yapılan yırtılma dayanımı testinde Blueprint Xcreme en yüksek ortalama yırtılma dayanımı değerlerine sahipken (1.08±0.19 N/mm) Alginelle en düşük ortalama yırtılma dayanımı değerlerini göstermiştir (0.51±0.3 N/mm). 120 saat saklama süresi sonunda Hydrogum 5 en yüksek ortalama yırtılma dayanımı değerlerine sahipken (1.15± 0.12 N/mm) Alginelle en düşük ortalama yırtılma dayanımı değerlerini göstermiştir (0.55±0.04 N/mm).

**Sonuç:** Test edilen uzatılmış model elde etme süresine sahip ticari irreversible hidrokolloid ölçü malzemelerinin tümü, yırtılma dayanımlarını 120 saatlik saklama süresi sonunda korumuştur.

**Anahtar kelimeler:** Yırtılma Dayanımı, İrreversible Hidrokolloid, Ölçü Malzemesi, Saklama Süresi

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**Yazışma Adresi / Corresponding:** Volkan Şahin,
Department of Prosthodontics, Faculty of Dentistry, Kirikkale University, Yahsihan, 71450 Kirikkale, Turkey
**Tel:** +90 318 224 49 27/7258
**Fax:** +90 318 225 06 85
**E-mail:** vlknshn@kku.edu.tr

## Introduction

Constructing a cast is an inevitable step in numerous dental procedures, mostly to design and fabricate either fixed or removable dentures. Casts are made from impression moulds, which represent negative imprints of dental structures.(1) Meticulous replicas of intra-oral and extra-oral tissue require accurate impression moulds. In other words, more precise the impression is, more accurate is the representation of oral structure by cast. Irreversible hydrocolloid impression materials, more commonly known as alginates are one of the most frequently used dental impression materials due to their advantages such as being simple, cost effective, hydrophilic, and ability to record finer details.(2)

Dental impressions might tear during either impression removal from mouth or cast removal from the impression. (3) Irreversible hydrocolloid impression materials are likely to stick to teeth due to alginate radicals bonding chemically to hydroxyapatite crystals of the enamel. (4) In addition, tear strengths of irreversible hydrocolloid impression materials are not high. (5) Although irreversible hydrocolloid impression materials might capture sub-gingival anatomy and contour, there is possibility of tearing of these materials during removal. Defects in the impression, caused by tearing, influence precision of the final casts.(6) Moreover, there are some reports on inflammation reaction in patients due to the irreversible hydrocolloid impression material remnants in gingival sulcus. (7) Therefore, imposed tensile stresses must be endured by irreversible hydrocolloid impression materials in order to prevent rupture. (8) These materials are most likely to tear in interproximal spaces and gingival crevices. (9) Strength of impressions is a key material characteristic that governs the performance of the final restorations. In other words, tear strength acts as an indicator for the stability of these impressions and has remarkable clinical significance. Thus, having high tear strength at the time of removal is necessary to make accurate gypsum cast that creates the initial base for a prosthetic appliance. (10)

Irreversible hydrocolloid impression materials are one of the most frequently used impression materials, despite their disadvantages such as poor dimensional stability. (4) To overcome this problem; conventional irreversible hydrocolloid impression materials generally need to be poured immediately or until 12 minutes; otherwise distortion appears as a major issue. (11,12) New generation of irreversible hydrocolloid impression materials, called extended-pour irreversible hydrocolloid impression materials, are designed to postpone pouring up impressions with cast material under particular storage conditions. The recent commercial extended-pour irreversible hydrocolloid impression materials' manufacturers claim these materials to maintain their dimensional stabilities up to 120 hours.(13,14) Number of different tests can be used to measure the tear strengths of impression materials. To measure tear propogation, Trouser tear test (15-17) and Die C tear tests are some of these methods. (18,19) International standard ISO 21563:2013 offers guidelines to evaluate tear strengths of irreversible hydrocolloid impression materials and specifies the use of a Die C tear specimen for tear strength measurements. (20) Also, Boghosian and Lautenschlager (21) have developed a more clinically pertinent tear strength specimen that imitates thin sheet of impression in inter-dental spaces and gingival crevices and was used in some elastomeric impression material studies. (9)

The aim of this in-vitro study was to evaluate the effect of prolonged storage times on the tear strength of extended-pour irreversible hydrocolloid impression materials. Tested null hypothesis ($H_0$) was that storage time had no influence on the tear strengths of extended-pour irreversible hydrocolloid impression materials.

## Material and Methods

Eighty four specimens were fabricated from five commercial and one experimental formulated extended-pour irreversible hydrocolloid impression materials utilising a polymeric specimen forming mould plate (Fig. 1) described in ISO 21563:2013 standard effective for irreversible hydrocolloid impression materials. The specimen forming mould plate was conditioned in a laboratory oven (Protherm PLF 130/18, Alser Teknik, Ankara, Turkey) at 35±2°C for at least 15 minutes before each specimen forming step. Extended-pour irreversible hydrocolloid material powders were mixed with deionized water at 23°C with the help of an alginate mixer unit (AM100; Shanghai Foshion Medical Instrument Co. Ltd, Shanghai, China) for 8 seconds with the required powder/water ratio recommended by the manufacturers' (Table 1). After removing the mould from the oven, the mould cavity was slightly overfilled with the mixed extended-pour irreversible hydrocolloid impression materials and a timer was started immediately to obtain the final shape of the specimen within 60 seconds. The specimen containing

**Table 1.** Extended-pour irreversible hydrocolloid material brands, manufacturers, recommended powder/water ratios, setting times and recommended intra-oral setting periods

| Material | Manufacturer | Powder/Water ratio (g/ml) | Setting Time | Recommended intra-oral setting period |
|---|---|---|---|---|
| Hydrogum 5® | Zhermack Spa,Italy | 14g/30ml | 110 s | 45 s |
| Alginmax ® | Major Prodotti Dentari Spa,Italy | 19g/40ml | 120 s | 40 s |
| Kromopan ® | Lascod Spa,Italy | 18g/40ml | 135 s | 30 s |
| Alginelle ® | Lascod Spa,Italy | 18g/40ml | 135 s | 30 s |
| Blueprint Xcreme ® | Dentsply Sirona, USA | 15.86g/34ml | 150 s | < 60s |
| Experimental | ---------- | 17g/40ml | 140 s | 30 s |

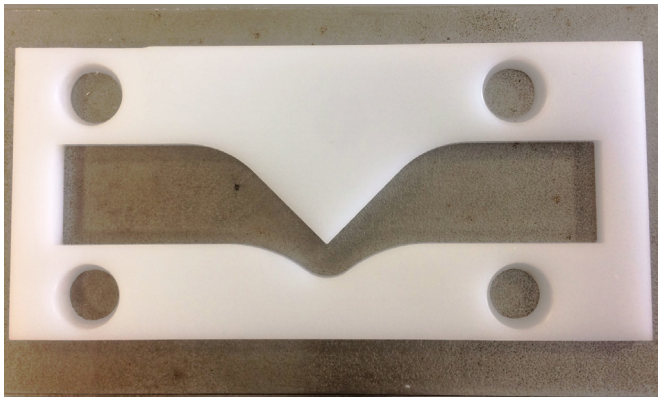

**Figure 1.** Polymeric specimen forming mould plate

mould was transferred to a hot water bath held at 35±2°C to simulate the recommended intra-oral setting periods by the manufacturers (Table 1). After removal of the specimen containing mould from the water bath, the specimen was separated from the mould. A dial indicator ((2112-101F; Insize Inc, Loganville, GA,USA) was used to measure thickness of the specimen at a point centred and just inside the apex of the 90° angle edge and the measured thickness was recorded. The specimens were randomly divided into two groups (n=7). Sample sizes were determined based on the ISO: 21563:2013 standard. Tear strengths of the first group providing the base line measurements were determined with the following procedure: The specimen was aligned and secured in the gripping mechanism of a custom fabricated universal test machine and loaded in tension until rupture with a crosshead speed of 500 mm/min within 90 seconds after removal of the specimen containing mould from the water bath. The force required to achieve rupture was recorded. Using following equation described in the ISO 21563:2013 standard, the tear strength, , for each specimen was calculated to the nearest 0.01 N/mm:

$$T_s = \frac{F}{d} \qquad (1)$$

Where F is the maximum force in Newton applied to cause rupture of the specimen and d is the specimen thickness in mm. Calibration of the universal test machine was checked prior to each test and all the specimen fabrication and test procedures were performed in accordance with the ISO 21563:2013 standard.

Specimens in the second group (n=7) were individually stored inside clear plastic zipper bags held at 23°C for additional 120 hours after fabrication as recommended by the manufacturers. Tear strength of for each specimen was calculated following the same procedures.

Data were analyzed with statistical software (SAS Studio 3.6; SAS Institute Inc, USA). Two-way analysis of variance (ANOVA) was used to analyze the data (brand, duration) for significant differences. Tukey's least squares means test was used to perform multiple comparisons (α=.05).

## Results

The results of the two-way ANOVA (brand, duration) are represented in Table 2. The tear strengths of the extended-pour irreversible hydrocolloid impression materials were affected by brand ($p<0.0001$) and brand-storage time interaction ($p=0.005$).

**Table 2.** Two-way ANOVA results

| Source | DF | Type III SS | Mean Square | F Value | p |
|---|---|---|---|---|---|
| Brand | 5 | 2.87199167 | 0.57439833 | 44.30 | <0.0001 |
| Duration | 1 | 0.01629643 | 0.01629643 | 1.26 | 0.2660 |
| Brand x Duration | 5 | 0.23858214 | 0.04771643 | 3.68 | 0.0051 |

**Table 3.** The mean values and multiple comparison test results for each individual parameters tested

| Brand | Tear Strength at baseline (N/mm) (X±σx) | Tear Strength after 120 hours of storage (N/mm) (X±σx) |
|---|---|---|
| Alginelle ® | 0.51 ±0.03 $D_a$ | 0.55±0.04 $D_a$ |
| Alginmax ® | 0.67±0.08 $CD_b$ | 0.89±0.13 $B_a$ |
| Blueprint Xcreme ® | 1.08±0.19 $A_a$ | 1.00±0.14 $AB_a$ |
| Hydrogum 5 ® | 1.05±0.07 $AB_a$ | 1.15±0.11 $A_a$ |
| Kromopan ® | 0.86±0.09 $BC_a$ | 0.78±0.12 $C_a$ |
| Experimental | 0.90±0.11 $AB_a$ | 0.87±0.12 $BC_a$ |

The mean values and multiple comparison test results for each individual parameters tested are presented in Table 3. Storage time did not influence the tear strength of the extended-pour irreversible hydrocolloid impression materials tested except Alginmax whose mean tear strengths increased after 120 hours of storage ($p<0.05$). At base line measurements Blueprint Xcreme provided the highest mean tear strength values (1.08±0.19 N/mm) whereas Alginelle provided the lowest mean tear strength values (0.51±0.3 N/mm). Hydrogum 5 provided the highest tear strength values after 120 hours of storage (1.15± 0.12 N/mm) whereas Alginelle provided the lowest mean tear strength values (0.55±0.04 N/mm).

## Discussion

Extended-pour irreversible hydrocolloid impression materials enabled delayed pouring of casts up to 120 hours compared to conventional irreversible hydrocolloid impression materials which required the casts to be poured immediately or within 12 minutes after removal from the mouth.(11,12) The irreversible hydrocolloid impression materials utilised in the current in-vitro study were chosen from materials available in the dental market whose manufacturers claim that the impressions made using these materials are dimensionally stable up to 120 hours in controlled storage conditions. The ISO 21563:2013 standard refers to hydrocolloid impression materials and the tests mentioned refer to conventional irreversible hydrocolloid impression materials. Therefore the tests applicable to irreversible hydrocolloid impression materials simulate clinical conditions where the impressions

removed from the mouth immediately undergo the testing procedures where any testing procedures for the extended-pour irreversible hydrocolloid impression materials haven't been specified. Since tear strength of irreversible hydrocolloid impression materials determine their resistance to tear during either impression removal from mouth or cast removal from the impression (3) and possible alterations of tear strength of extended-pour irreversible hydrocolloid impression materials subjected to a prolonged storage time might result in damaged plaster casts during cast removal from the impression; a modified test procedure was utilised in order to determine the tear strengths of extended-pour irreversible hydrocolloid impression materials subjected to a prolonged storage time. Specimens subjected to 120 hours of storage time were individually stored inside clear plastic zipper bags held at 23°C as recommended by the manufacturers and consistent with the procedure previously used for determining the dimensional stabilities of such materials.(14)

Since the results of the current in-vitro study indicated that the tear strengths of the extended-pour irreversible hydrocolloid impression materials are dependent on the materials brand rather than the storage time, the tested null hypothesis ($H_0$) was accepted except the Alginmax whose mean tear strengths increased after 120 hours of storage. Possible explanation of this increase of tear strength might be related to the setting time stated by the manufacturer not being accurate and the impression material didn't have enough time to accomplish gelation reaction in the stated period. Therefore, extended storage time provided the time to finish gelation reaction and endure higher tensile stresses for this material. The minimum variation of tear strength after 120 hours of storage determined for the experimental formulated extended-pour irreversible hydrocolloid impression material indicates significance of gelation process's accomplishment within stated setting time supports this fact.

The effect of extended-pour irreversible impression materials' brand on the tear strength is possibly dependent on the materials' chemical composition and needs to investigated on further studies. However since the minimum tear strength value for irreversible hydrocolloid impression materials is stated as 0.38 N/mm in ISO 21563: 2013 standard, all the materials tested complied with this standard in terms of tear strength values.

A possible limitation of this in-vitro study is related to the test procedure on determining tear strength values of irreversible hydrocolloid impression materials the thickness of the specimen just in the moment of tearing is not required to calculate tear strength in the ISO 21563: 2013.

## Conclusion

Within the limitations of this in-vitro study; it was concluded that all the commercial extended-pour irreversible hydrocolloid impression materials tested maintained their tear strengths after 120 hours of storage and plaster casts can be safely removed from commercial extended-pour irreversible hydrocolloid impression materials after delayed pouring time of 120 hours under controlled conditions.

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