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Research Article

Effect of Chloroform Exposure on Tensile Properties of Dental Rubber Dams

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Abstract

Aim: This study investigates the effect of chloroform exposure on the tensile strength and elongation of dental rubber dams with the clinical goal of preserving isolation and limiting solvent leakage.

Methods: Sheet specimens of five rubber dams (Brasseler TRUE, Coltene HySolate, Coltene Flexi Dam, Cranberry Carbon, Ultradent DermaDam) were cut into 15×85 mm strips. Each specimen was clamped 35 mm at both ends, leaving a 15 mm gauge. A custom device pre-stretched the gauge from 15 to 30 mm before exposure to chloroform. Treated specimens (n=12) received 20 µL chloroform across the stretched gauge while controls (n=12) received no solvent. Immediately after drying of the solvent, the treated specimens were tested on Instron Universal Test Machine 5566Q4935 using a crosshead speed of 50 mm/min. The outcomes were tensile stress and elongation. Data were analyzed using within-product t-tests ($\alpha=0.05$) and one-way ANOVA with Tukey post hoc ($\alpha=0.05$).

Results: After exposure to chloroform, Brasseler TRUE and Ultradent DermaDam showed no significant reduction in tensile strength (Brasseler $p=0.71$, Ultradent $p=0.26$) with increased elongation, and Brasseler TRUE maintained the highest post-treatment mean strength. Coltene HySolate demonstrated a moderate strength reduction ($p<0.01$) with decreased elongation. Cranberry Carbon and Coltene Flexi Dam showed a significant reduction in tensile strength ($p<0.001$) with marked decreases in elongation.

Conclusion: Brasseler TRUE and Ultradent DermaDam were the most resistant to chloroform exposure with minimal changes in tensile properties. When chloroform use is anticipated, choosing more resistant dams and controlling solvent spread can reduce tearing and isolation failure.

Keywords: *Endodontics, Chloroform, Tensile Strength, Rubber Dam*

Introduction

Non-surgical endodontic retreatment requires removal of the existing root canal filling material so the canal system can be re-instrumented, disinfected, and re-obturated. Because gutta percha is often difficult to remove completely with instruments alone, solvents have long been used as adjuncts to soften filling materials and improve penetration of hand or rotary instruments.

Chloroform has historically remained one of the most commonly used gutta-percha solvents because of its rapid dissolving ability and practical chairside use, and earlier studies showed that it can facilitate removal of gutta-percha and carrier-based obturation materials during retreatment (1, 2, 3, 4).

Chloroform remains clinically relevant not only for gutta percha softening, but also because it may contribute to canal disinfection during retreatment. Chloroform use has been associated with significantly reduced intracanal cultivatable *Enterococcus faecalis* compared with saline, suggesting an added antimicrobial effect during filling removal (5). At the same time, concerns regarding toxicity and exposure have led to continued investigation of its safety and alternatives. Controlled-use studies reported that operatory chloroform vapor levels remained below occupational limits, and the quantity of solvent expressed apically during retreatment was measured at levels far below toxic dose thresholds (6, 7). Recent studies have also continued to evaluate chloroform and other solvents for regaining patency in canals obturated with bioceramic sealers, supporting its continued clinical relevance in retreatment procedures (8, 9).

However, limited information is available regarding the effect of chloroform on the rubber dam itself. During retreatment, chloroform may leak onto the dam when suction is inadequate or be inadvertently transferred during delivery to the access cavity. Because the rubber dam is under tension around the clamp and tooth, even brief solvent contact may alter its tensile properties, increase tearing risk, and compromise isolation.

The aim of this study was to evaluate the effect of chloroform exposure on the tensile properties of five commercial rubber dams and identify materials that are more resistant or more vulnerable to solvent-related weakening.

Materials and Methods

Rubber dam groups and specimen preparation

Five commercially available rubber dams were evaluated: Coltene HySolate, Brasseler TRUE latex-free dental dam, Coltene Flexi Dam, Cranberry Carbon, and Ultradent DermaDam. For each material, control and chloroform-treated specimens were prepared, resulting in 10 groups total, with 12 specimens per group. Each rubber dam sheet was cut into strips measuring 15 × 85 mm. During testing, 35 mm of each end was secured vertically in the Instron grips, leaving a 15 mm central gauge length.

Before testing, the thickness of each specimen was measured using a Rexbeti micrometer (Fig. 1). Thickness values were used for normalization and calibration in the Instron software so that tensile stress could be calculated from the recorded load. To simulate clinical tension around a clamped tooth, a custom stretching device (Fig. 2) was fabricated to elongate the 15 mm central test region to 30 mm before solvent application.

Figure 1. Rubber dam thickness measurement.

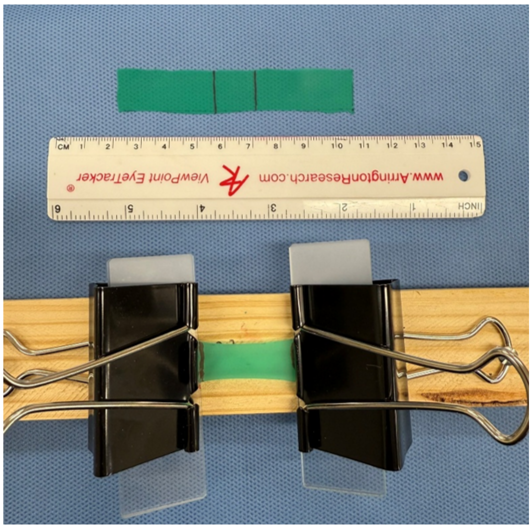

Figure 2. Custom device for pre-stretching the rubber dam specimen.

Chloroform application

For the treated groups, 20 µL of chloroform was applied evenly to the pre-stretched central region using a Gilson Pipetman P20 pipette (Fig. 3). Chloroform was delivered directly to the center of the stretched gauge region to simulate accidental contact of solvent with a rubber dam during endodontic retreatment. Control specimens received no chloroform. After application, the specimens were mounted for tensile testing.

Tensile properties test

All specimens were tested on an Instron universal testing machine (Fig. 4). Tensile loading was performed at a crosshead speed of 50 mm/min until failure. The following properties were recorded for each specimen: maximum force (N), tensile stress at maximum force (MPa), and displacement at maximum force (mm). Maximum force represented the highest load sustained by the specimen during testing. Tensile stress at maximum force was calculated by normalizing force to the specimen cross-sectional area, and displacement at maximum force represented the extension at the point of peak load.

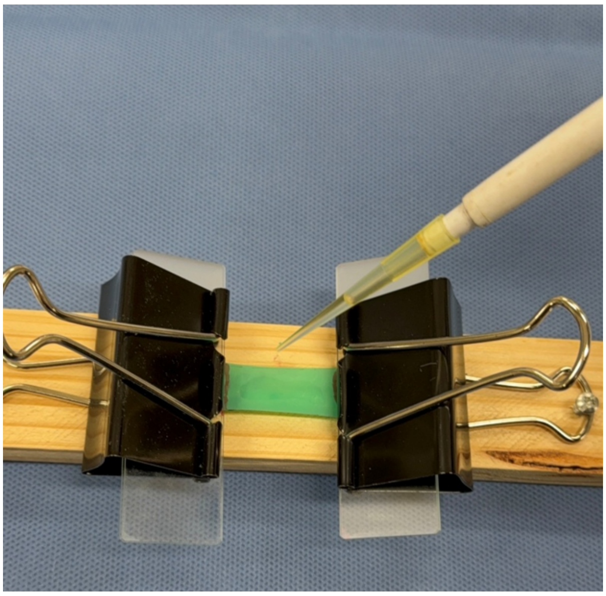

Figure 3. Chloroform application with a Gilson Pipetman P20 pipette.

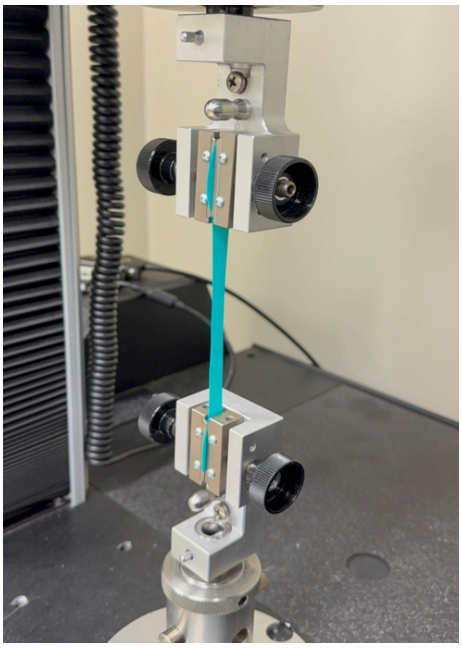

Figure 4. Instron Universal testing machine for tensile properties testing.

Statistical analysis

Data were analyzed using within-product t-tests to compare control and chloroform-treated specimens for each rubber dam type. Inter-product comparisons were performed using one-way ANOVA with Tukey post hoc testing. The significance level was set at $\alpha = 0.05$ for t-tests and $\alpha = 0.001$ for ANOVA with Tukey post hoc analysis.

Results

Tensile stress at maximum force

Chloroform exposure produced clear, product-specific changes in tensile behavior. Brasseler TRUE (7.69 ± 2.16N vs. 7.41 ± 1.31 N, $p = 0.71$) and Ultradent DermaDam (6.32 ± 0.98 N vs. 5.72 ± 1.49 N, $p = 0.26$) showed no significant reduction in tensile stress at maximum force, and Brasseler TRUE maintained the highest post-treatment mean strength. Coltene HySolate demonstrated a moderate reduction in tensile stress (10.74 ± 3.30 vs 6.12 ± 2.88 N, $p < 0.01$). In contrast, Cranberry Carbon (7.82 ± 2.29 N vs 2.57 ± 1.49 N) and Coltene Flexi Dam (1.10 ± 0.096 N vs 0.43 ± 0.22 N $p < 0.001$). showed marked reductions after chloroform exposure and, ANOVA with Tukey post hoc analysis confirmed significant inter-product differences.

Table 1. Tensile stress at maximum force (N) before and after chloroform exposure.

Rubber dam material	Control (Mean ± SD)	Chloroform (Mean ± SD)	p value
Brasseler TRUE	7.69 ± 2.16	7.41 ± 1.31	0.71
Ultradent DermaDam	6.32 ± 0.98	5.72 ± 1.49	0.26
Coltene HySolate	10.74 ± 3.30	6.12 ± 2.88	<0.01
Cranberry Carbon	7.82 ± 2.29	2.57 ± 1.49	<0.001
Coltene Flexi Dam	1.10 ± 0.096	0.43 ± 0.22	<0.001

ANOVA: Significant inter-product differences were detected both before and after chloroform exposure (one-way ANOVA, Tukey post hoc test, *p* < 0.05).

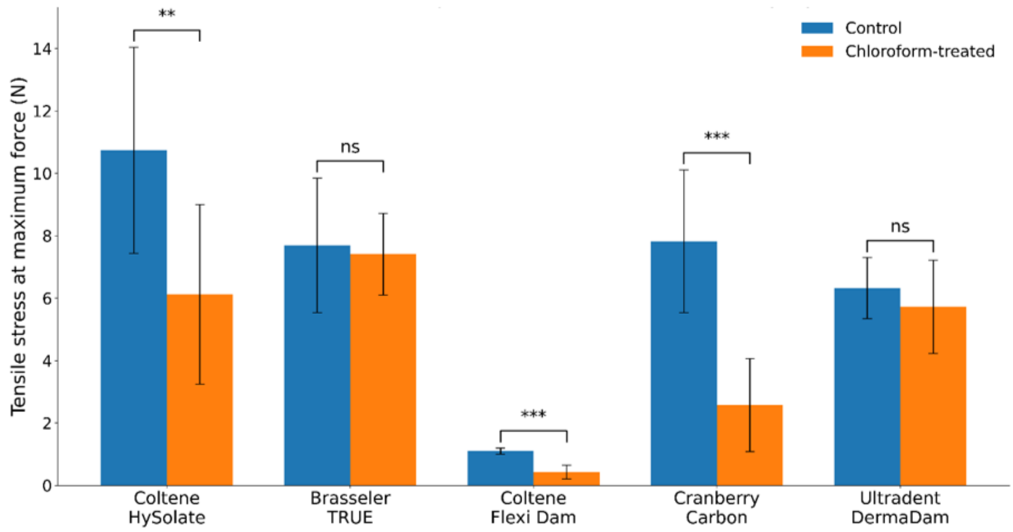

Figure 5. Effect of chloroform exposure on rubber dam tensile properties. * p < 0.05, ** p < 0.01, *** p < 0.001, ns = not significant. Bars represent mean ± SD.

Displacement at maximum force

Displacement was significantly altered in all five rubber dam materials after chloroform exposure. Brasseler TRUE and Ultradent DermaDam showed increased displacement (455.15 ± 45.39 vs 512.67 ± 29.94 mm, p < 0.001; 424.95 ± 20.45 vs 460.28 ± 25.84 mm, p < 0.01). Coltene HySolate showed a decrease in displacement (306.71 ± 30.73 vs 255.96 ± 68.52 mm, p < 0.05). The greatest reductions were observed in Coltene Flexi Dam and Cranberry Carbon, which decreased from 331.48 ± 28.13 to 179.88 ± 96.36 mm and from 261.90 ± 25.77 to 164.73 ± 62.92 mm, respectively (p < 0.001). ANOVA with Tukey post hoc analysis also confirmed significant inter-product differences in displacement.

Table 2. Displacement at maximum force (mm) before and after chloroform exposure.

Rubber dam material	Control (Mean ± SD)	Chloroform (Mean ± SD)	p value
Brasseler TRUE	455.15 ± 45.39	512.67 ± 29.94	<0.001
Ultradent DermaDam	424.95 ± 20.45	460.28 ± 25.84	<0.01
Coltene HySolate	306.71 ± 30.73	255.96 ± 68.52	<0.05
Coltene Flexi Dam	331.48 ± 28.13	179.88 ± 96.36	<0.001
Cranberry Carbon	261.90 ± 25.77	164.73 ± 62.92	<0.001

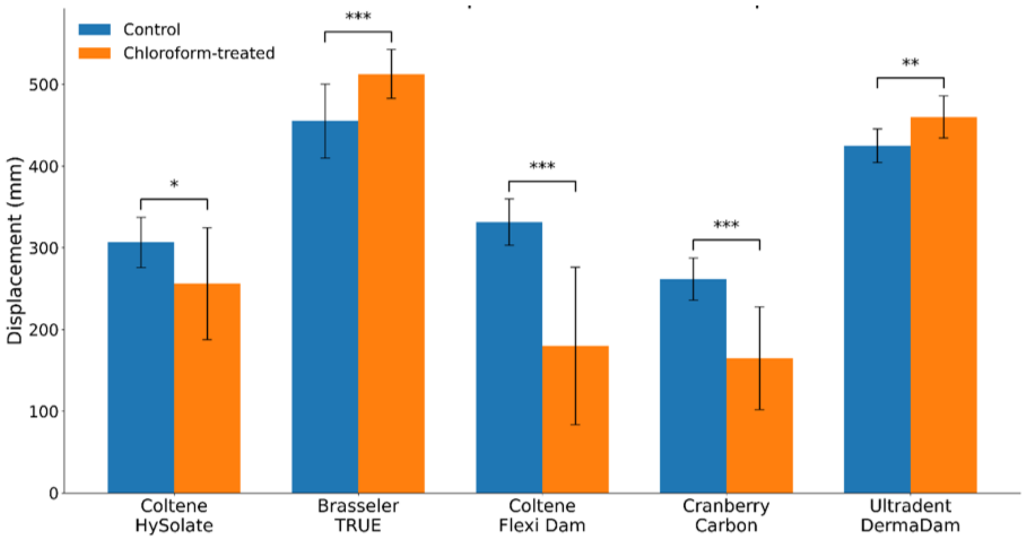

Figure 6. Effect of chloroform exposure on rubber dam displacement. * p < 0.05, ** p < 0.01, *** p < 0.001, ns = not significant. Bars represent mean ± SD.

Overall findings

Overall, Brasseler TRUE and Ultradent DermaDam were the most stable after chloroform exposure, whereas Cranberry Carbon and Coltene Flexi Dam were the most adversely affected. These findings indicate that the effect of chloroform on rubber dam tensile behavior is material dependent and that clinically relevant differences exist in resistance to solvent exposure.

Discussion

The present findings broaden the endodontic retreatment studies by demonstrating that chloroform may affect not only obturation material removal, but also the integrity of the rubber dam itself under simulated clinical tension. This distinction is clinically relevant because prior investigations have focused primarily on retreatment efficiency and solvent-related effects on canal patency. Halothane has been reported to perform similarly to chloroform in gutta-percha removal, whereas hydrochloric acid may improve patency in bioceramic retreatment but may also increase dentin erosion (1, 8). In contrast, the effect of accidental solvent contact on the rubber dam barrier has received little attention.

From a clinical standpoint, the findings suggest that rubber dam performance in retreatment is product-specific rather than simply latex versus non-latex. Among the five rubber dams tested, HySolate and Cranberry Carbon were latex-based materials, Brasseler TRUE and Ultradent DermaDam were synthetic polyisoprene materials, and Coltene Flexi Dam was a thermoplastic elastomer-based non-latex material. Although Brasseler TRUE and Ultradent DermaDam maintained tensile behavior better than the other products, Coltene Flexi Dam was substantially weakened despite also being a non-latex material, suggesting that polymer formulation and material design likely influence resistance to chloroform. This observation is clinically important because a weakened dam may tear more easily once stretched around a clamp or tooth, even after brief solvent contact. Because controlled solvent use remains recommended and small quantities are generally considered safe when confined to the canal, careful delivery and suction remain essential to minimize unintended contact with the dam and preserve isolation (7).

Several limitations should be considered when interpreting these findings. This was an in vitro bench-top model using a single solvent volume, one testing speed, and immediate post-exposure testing. In addition, flat strip specimens were used rather than punched rubber dam sheets positioned around teeth and clamps, so actual leakage behavior and tearing around a clinical perforation were not measured directly. Further investigation should evaluate repeated exposure, additional retreatment solvents, puncture resistance, tearing around punched holes, and time-dependent material changes.

Conclusion

Brief chloroform exposure can significantly alter the tensile properties of dental rubber dams under simulated retreatment conditions. Brasseler TRUE and Ultradent DermaDam were the most stable after exposure, whereas Cranberry Carbon and Coltene Flexi Dam were the most vulnerable, with Coltene HySolate showing an intermediate reduction in performance. These findings support that rubber dam selection matters when chloroform use is anticipated during retreatment. In addition to careful solvent delivery and high-volume suction, choosing a more chloroform-resistant dam may help preserve isolation, reduce tearing, and decrease the risk of leakage or accidental ingestion of toxic liquids.

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Conflict of Interest

The authors deny any conflicts of interest related to this study.

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