

Effect of various disinfectant solutions on the tensile strength of gutta-percha using the rapid sterilization technique

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Abstract

Context: Gutta-percha (GP) gets contaminated during handling. It becomes imperative to ensure GP is sterile before placement in root canal space.

Aims: The aim of the study was to evaluate and compare the tensile strength of GP treated with four different disinfectant solutions: 3% sodium hypochlorite (NaOCl), amla juice (AJ), *Aloe vera* (AV) juice, and pancha tulsi (PT).

Settings and Design: The study design was an *in vitro* study.

Materials and Methods: Fifty GP cones with a size of 30 were procured from sealed packages in five different groups. Experimental groups were disinfected for 1 min with 3% NaOCl, AJ, AV, and PT except the control group. Tensile and Brinell Testing Machine is used to measure the tensile strengths of GP.

Statistical Analysis Used: Results were subjected to statistical analysis using the Kruskal–Wallis test followed by Dunn’s *post hoc* test.

Results: The mean tensile strength values for Groups A, B, C, D, and E are 9.49 Mpa, 13.33 Mpa, 12.58 Mpa, 12.69 MPa, and 13.56 MPa, respectively. In the herbal disinfectant group, such as AJ, AV, and PT, the tensile strength was not significantly altered, whereas in the 3% NaOCl group, it was reduced considerably.

Conclusions: AJ, AV juice, and PT as a GP disinfectant do not alter the tensile strength of GP cones.

Keywords: *Aloe vera* juice; amla juice; disinfection; gutta-percha cones; pancha tulsi; sodium hypochlorite; tensile strength

INTRODUCTION

The main aim of endodontic treatment is to ensure absolute aseptic conditions during the entire root canal procedure, starting from the access opening to permanent coronal restoration. To achieve a favorable result in endodontic

therapy, it is crucial to eliminate or reduce the number of bacteria under sterile conditions.^[1] The obturating material often used to fill the root canal is gutta-percha (GP), which is obtained from sealed packages.

Before the obturation, it is necessary to disinfect GP cones due to potential contamination that may occur during handling.^[2] GP cones are not suitable for physical sterilization.

Procedures such as hot air oven and autoclaving cannot be used to disinfect GP cones due to their physical and

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chemical properties. Therefore, it is necessary to quickly disinfect the cones using chemical solutions.^[3] Various chemicals such as ethyl alcohol, formocresol, sodium hypochlorite (NaOCl), and paraformaldehyde can be used to disinfect GP cones, which typically take 1–25 min.^[4] It is important to choose the appropriate disinfectant for GP cones, as it can affect their mechanical properties and surface texture, potentially compromising the success of the obturation process.

NaOCl solution, known for its broad-spectrum antibacterial properties, is extensively researched as a chemical solution for disinfecting GP.^[5–8] NaOCl is a powerful oxidizing agent and decontaminant that rapidly weakens GP cones, reducing their strength and affecting the adherence of sealers.^[9] In addition, the use of 5.25% NaOCl results in the formation of cuboidal-shaped crystals and thereby reduces the tensile strength of GP cones. Eventually, this might affect the sealing ability of GP and overall long-term prognosis of endodontic treatment.^[10]

The popularity of herbal medicines has increased as individuals seek cost-effective, readily available, and organic alternatives.^[11] Herbal remedies encompass a wide range of applications, including antimicrobials, anticancer, antidiabetic, immunological modulatory, respiratory illnesses, liver difficulties, and cosmetics agents.

Although extensively accessible in the Indian market, there is a lack of evidence about the utilization of these substances as disinfectants in endodontic therapy.^[12–14] Consequently, herbal solutions such as amla juice (AJ), pancha tulsi (PT), and *Aloe vera* (AV) juice were employed in the present study.

When it comes to disinfecting GP cones, it is preferable to choose a chemical that is both effective and safe.^[15] The disinfection solutions utilized in this research consisted of 3% NaOCl from Versons, India; AV juice from Patanjali Ayurved Ltd., India; PT from The Unati Co-op. Marketing-Cum Processing Ltd., India; and AJ from The Unati Co-op. Marketing-Cum Processing Ltd., India.

AV gel has demonstrated efficacy in decontaminating GP cones and exhibits bacteriostatic activity against *Salmonella paratyphi*, *Staphylococcus aureus*, and *Streptococcus pyogenes*.^[16,17]

Tulsi has been utilized in recent studies for the management of cancer including conditions such as oral lichen planus, leukoplakia, and other precancerous lesions and conditions. The antibacterial property of tulsi is attributed to its abundance of bioactive chemicals.^[18] In addition, AJ, containing phytochemical components such as tannins, serves as an effective disinfectant. A decoction of amla leaves is utilized as a nonchemical antibacterial

mouthwash. Furthermore, studies have shown that amla extract is equally as efficient as ethylenediaminetetraacetic acid in eliminating the smear layer.^[19]

The herbal disinfectant used as a chairside GP disinfection solution exhibits effective antibacterial properties. However, further research is needed to determine its ability to maintain its physical characteristics. The aim of this study was to assess and compare the tensile strength of GP that has been treated with a 3% NaOCl solution. Disinfectant solutions include AJ, AV juice, and PT.

MATERIALS AND METHODS

Method of disinfection

In this study, 50 GP (DiaDent, Netherlands, Korea) cones of size 30, 6% were obtained from sealed packages. The samples were divided into five different groups, with each group including ten samples. The current study comprises a control group and four experimental groups, each utilizing a different disinfection solution.

The disinfectants utilized in the experimental groups were:

- Group A – 3% solution of NaOCl (Versons, India) ($n = 10$)
- Group B – AV juice (Patanjali Ayurved Ltd., India) ($n = 10$)
- Group C – PT (The Unati Co-op. Marketing-Cum Processing Ltd., India) ($n = 10$)
- Group D – AJ (The Unati Co-op. Marketing-Cum Processing Ltd., India) ($n = 10$)
- Group E – Control (No disinfectant used) ($n = 10$).

In the control group, GP cones remained intact without undergoing disinfection. The experimental samples underwent disinfection in a sterile petri dish for a duration of 1 min. Subsequently, each sample was individually transferred, and it should be rinsed in distilled water (5 mL) for 1 min. Finally, the samples were left to dry in sterile Petri dishes that included sterile filter paper pads. Mechanical testing was conducted on all GP cones to assess their tensile strength.

Analysis of mechanical properties

The mechanical parameters of each sample such as its tensile strength were measured using a Tensile and Brinell Testing Machine (TERCO, MT-3017, Sweden). Each cone was standardized to a length of 14 mm by cutting the base of the cone. A specialized grip was used to insert the standardized cone, with a 2 mm margin on either side. The cones were positioned on the grip for the reduction of plastic deformation and thereby avoid sliding of cone while testing. Subsequently, the grips were mounted to the testing device, and the force applied to the GP cones was adjusted.

The final sample was subjected to testing measures 10 mm in length and had a cross-sectional area of 1.38 square

millimeters. The GP cones were subjected to tensile stress in grams and length in millimeters, with a “cross-head speed of 1 mm/min.” The testing equipment was connected to a computer, which displayed the results until the maximum tensile failure occurred. Subsequently, the tensile strength was evaluated by utilizing data obtained from the interconnected computer. The calculated data were converted to megapascals (MPa). The mean data of tensile bond strength (TBS) was analyzed using the Kruskal–Wallis test.

Pairwise comparisons were performed using the Dunn’s *post hoc* analysis.

RESULTS

In this study, we compared the average TBS using the Kruskal–Wallis test. The average TBS for Group A was 9.493 ± 0.465 , for Group B was 13.334 ± 0.772 , for Group C was 12.583 ± 1.174 , for Group D was 12.694 ± 0.677 , and for Group E was 13.563 ± 1.263 [Table 1]. There was a statistically significant difference in the average TBS between the groups ($P < 0.001$) [Table 1].

There was no significant difference in the mean TBS values between Group B and Group C ($P = 0.082$), Group B and Group D ($P = 0.064$), Group B and Group E ($P = 0.850$), Group C and Group D ($P = 0.939$), Group C and Group E ($P = 0.137$), and Group D and Group E ($P = 0.103$) [Table 2].

Mean tensile strength values for all groups are graphically illustrated in Figure 1.

DISCUSSION

Efficiently cleaning, shaping, disinfecting, and completely filling root canal system is essential for the success of endodontic treatment.^[20] One widely utilized material for filling the root canal space is the GP cone. It is widely recognized in endodontic therapy, that for preventing the contamination by bacteria in the root canal, cleaning of GP is essential before obturation.^[21] Root canal filling cones must

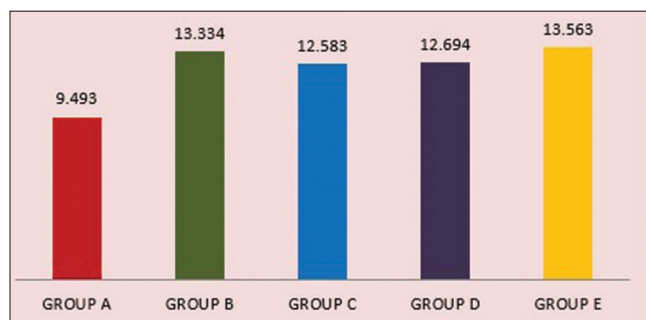


Figure 1: Bar graph showing mean tensile strength for each group

be capable of withstanding rigorous sterilization methods as they need to remain in the root canal for a prolonged duration. Various research have examined the effects of disinfection on the surface texture of GP cones.^[22-25]

It was determined that the GP cone’s mechanical properties adhere to Hook’s law, suggesting that it is a partially crystalline polymeric material. Multiple investigations have established a correlation between the tensile strength and the GP component of the GP cone. Conversely, the zinc oxide component present in the GP cones was found to have a correlation with the percentage of elongation and modulus of elasticity, whereas the flexibility of the cones was impacted by the wax and resin components.^[26]

According to Ingle, decontamination using the wiping technique has limitations, such as relying exclusively on physical contact to eliminate organisms and not providing sufficient time for chemical solutions to effectively target germs.^[27] To effectively sanitize a transparent cone, it can be immersed in a potent disinfectant solution for a prolonged duration.

Table 1: Comparison of mean tensile strength values of gutta-percha cones after disinfection with 3% sodium hypochlorite, aloe vera juice, amla juice, pancha tulsi, and disinfectants

Kruskal–Wallis ANOVA Tensile bond strength (Mpa)			
Disinfectants (group)	Sample size	Mean±SD	P
A - 3% NaOCl	10	9.493±0.465	<0.001*
B - AV	10	13.334±0.772	
C - AJ	10	12.583±1.174	
D - PT	10	12.694±0.677	
E - control	10	13.563±1.263	

* $P < 0.001$ - statistically significant, P - statistical significance. SD: Standard deviation, NaOCl: Sodium hypochlorite, AV: Aloe vera, AJ: Amla juice, PT: Pancha tulsi

Table 2: Dunn’s *post hoc* analysis for pair wise comparison

Pairwise comparisons Dunn’s <i>post hoc</i> analysis			
Group	Group	Mean difference	P
A - 3% NaOCl	Group B	-3.841	<0.001*
	Group C	-3.090	<0.001*
	Group D	-3.201	<0.001*
	Group E	-4.070	<0.001*
B - AV	Group C	0.751	0.082
	Group D	0.640	0.064
	Group E	-0.229	0.850
C - AJ	Group D	-0.111	0.939
	Group E	-0.980	0.137
D - PT	Group E	-0.869	0.103

* $P < 0.001$ - statistically significant, P - statistical significance. NaOCl: Sodium hypochlorite, AV: Aloe vera, AJ: Amla juice, PT: Pancha tulsi

The rationale for selecting a size 30 GP cone in this investigation was based on Weine's recommendation that the minimum apical preparation should extend to a size 30. Therefore, the master apical file with a size of 30 was chosen.

NaOCl is used as a disinfectant and an irrigation solution for a duration of 30 s in endodontic procedures. It should be noted that NaOCl is a powerful oxidizing agent, which may reduce the stability of the polymer chain, waxes, and resin present in GP cones. The mechanical properties of a GP cone would be adversely affected due to its chemical instability.^[28]

This study demonstrates that the tensile strength of the NAOCL group was markedly diminished in comparison to AV, AJ, and PT due to its potent oxidizing effects. There was a highly statistically significant difference ($P < 0.001$) between the NAOCL and AV groups. The results were consistent with the study conducted by Mahali *et al.*, which showed a considerable decrease in the tensile strength of GP compared to the control group and a substantial reduction compared to 90% AV.^[10]

Herbal disinfection solutions such as AV, PT, and AJ have exhibited antibacterial, antioxidant, and anti-inflammatory properties. PT and AJ exhibit strong antibacterial properties when tested against *S. aureus* and *Enterococcus faecalis*, making them effective disinfection agents against Gram-positive bacteria. The study results demonstrated that PT and AJ had excellent antibacterial efficacy, which was comparable to that of 3% NaOCl.^[29]

The current investigation found that AV, PT, and AJ preserved the tensile strength of the GP cone without causing significant alterations compared to the control group. AV juice is a disinfectant solution that contains various compounds such as anthraquinones, saponins, ascorbic acid, sterols, cinnamic acid, p-coumaric acid, and pyrocatechol.^[30] These compounds are responsible for the antibacterial properties of AV juice. In the current study, the AV group exhibited the highest tensile strength. AV, when used as a quick disinfectant solution for chairs, did not cause any changes in the surface structure or crystal formation after being disinfected for 1 min. The results of the current study are in concordance with that of Ismail *et al.* The control group exhibited the highest tensile strength. When GP cones were disinfected using a solution of 5.25% NaOCl compared to a gel containing 90% AV, there was a notable decrease in the tensile strength of the NaOCl-treated cones in comparison to the AV-treated cones. Recent research has indicated that AV can serve as both a lubricant for canals and an intracanal medicament.^[31]

The intense disinfection activities of PT may be attributed to the presence of other bioactive components such as

alkaloids, glycosides, tannins, anthraquinones, steroidal terpenes, cardiac saponins, resins, polysaccharides, flavonoids, glycosides, and steroidal rings. Furthermore, the present investigation shows that the components of PT do not modify the physical properties of GP when subjected to a 1-min disinfection process. Makade *et al.*^[4] conducted a study to evaluate the effectiveness of three herbal gels (lemon, tulsi, and green tea) in cleaning GP cones. Their findings indicated that all of the gels exhibited inhibition zones in the vicinity of 5.25% NaOCl.

AJ contains high levels of Vitamin C and acts as an antioxidant. The presence of various phytochemical components, including alkaloids, tannins, terpenoids, pectin, flavonoids, gallic acid, quercetin, polyphenols, and Vitamin C, likely contribute to the enhanced disinfection properties of AJ. Shailaja *et al.*^[10] demonstrated that AJ possesses antibacterial properties and can be used as a disinfectant for general practitioners, with equivalent effectiveness to a 3% NaOCl solution. In the current study, when the tensile strength was assessed, there was a reduction in their initial values; however, this difference did not reach statistical significance. Regardless of the presence of the NaOCl group, there was no notable disparity in the tensile strength of GP cones that were disinfected with the AJ, AV, PT, and control groups.

CONCLUSIONS

The study concludes that AV, PT, and AJ are safer disinfectants for GP as they do not affect the tensile strength of GP, hence improving the strengthening of root canal and its sealing ability. In addition, further investigation is necessary to validate AV, PT, and AJ as more effective and safer fast chairside disinfectants for GP cones. This research should focus on studying the percentage of elongation and modulus of elasticity of GP cones using a larger sample size.

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Conflicts of interest

There are no conflicts of interest.

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