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# Comparative Evaluation Of Flexural Strength Of Human Radicular Dentin Sticks After Conditioning With Four Different Endodontic Chelating Agent: An In-Vitro Study

Dr. Ramchandra Kabir,
*Professor, Department Of Conservative Dentistry And Endodontics, MIDSR Dental College, Vishwanathpuram, Ambejogai Road, Latur.*

Dr. Shubham Galale,
*Post Graduate Student, Department Of Conservative Dentistry And Endodontics, MIDSR Dental College, Vishwanathpuram, Ambajogai Road, Latur.*

Dr. Amol Badgire,
*HOD And Professor, Department Of Conservative Dentistry And Endodontics, MIDSR Dental College, Vishwanathpuram, Ambajogai Road, Latur.*

Dr. Anita Kale,
*Professor, Department Of Conservative Dentistry And Endodontics, MIDSR Dental College, Vishwanathpuram, Ambajogai Road, Latur.*

Dr. Abhishek Badade,
*Reader, Department Of Conservative Dentistry And Endodontics, MIDSR Dental College, Vishwanathpuram, Ambajogai Road, Latur.*

Dr. Ajitkumar Shinde,
*Reader, Department Of Conservative Dentistry And Endodontics, MIDSR Dental College, Vishwanathpuram, Ambajogai Road, Latur.*

***Abstract***
*Introduction: The objective of this in vitro study was to examine flexural strength of human radicular dentin sticks after conditioning with four different endodontic chelating agent. Materials and Methods: Forty dentin sticks of (1 mm × 1 mm × 12 mm) were obtained from 10 single-rooted premolars and divided into four groups (n = 10). One stick from each tooth was assigned to one of the experimental groups and was soaked in one of the experimental chelating solutions for 5 min 17% Ethylenediaminetetraacetic acid (EDTA), 0.2% Chitosan (C), 10% Citric Acid (CA) plus 2% Chlorhexidine (CHX), or Saline (control group). Following the 5-min soak, the sticks' flexural strength was evaluated using a 3-point loading test using the universal testing machine. Results: Chitosan (0.2%) and Citric acid (10%) plus Chlorhexidine (2%) showed no significant detrimental effect on the flexural strength radicular dentin compared to the control. EDTA (17%) exhibited a significant drop in the flexural strength and microhardness of radicular dentin compared to the other groups. Conclusions: Chitosan and Citric Acid plus Chlorhexidine chelators do not compromise the surface and bulk mechanical properties of radicular dentin.*

***Keywords:*** *Ethylenediaminetetraacetic acid; Chitosan; Citric acid; Chlorhexidine; flexural strength*

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## I. Introduction

Chelating agents decalcify radicular dentin and eliminate the smear layer formed after the mechanical preparation of the root canal.[1] The smear layer acts as a barrier that precludes irrigants from directly reaching and disinfecting the dentin surface[2], the dentinal tubules, and altering the sealing quality of obturation.[3,4]

Chelating agents, such as Ethylenediaminetetraacetic acid (EDTA), is used as a gold standard strong chelator with proven smear layer removal capacity.[5,6] Since the smear layer contains both inorganic and organic

debris, sequential irrigation with sodium hypochlorite–EDTA is the most commonly used protocol to remove it.[7,8] This sequence shows a concentration and time-dependent erosion of the root canal dentin. However, the long-term usage of EDTA can reduce dentin's flexural strength and modulus of elasticity ultimately raising the risk of root fracture.[9]

Chitosan (C) is a naturally occurring, biodegradable amino polymer.[10] Even at low concentrations and over brief periods of time, chitosan acts as a chelating agent, demineralizing dentin in a way similar to that of EDTA.[11,12] Silva PV et al. (2012)[13] found 0.2% chitosan to be equally effective to 15% EDTA and 10% citric acid in smear layer removal and microhardness reduction.[14]

Citric acid (CA) being a weak organic acid, is utilized as a root canal irrigant to eliminate the smear layer.[15] Even though 10% CA has an equivalent smear layer removal efficiency to 17% EDTA, it is comparatively more biocompatible and causes less tissue irritation.[16].

The alternative combination of CA and Chlorhexidine (CHX) was proposed to offer a broad antimicrobial activity and the ability to remove smear layers, which may reduce tissue toxicity and simplify irrigation processes.[17] the addition of CHX to CA does not alter the solution's decalcifying qualities.[18] Also, such a combination has no effect on the adherence of root canal sealers or resin composite filling materials to the pulp chamber's dentine.[19]

Flexural strength (F) is a property studied to see how a material responds to complicated pressures that combine tensile, compressive, and shear stress.[20] Taking all these factors into consideration, this study was carried out to evaluate the flexural strength of human radicular dentin sticks after conditioning with four different endodontic chelating agents.

## II. Materials And Methods

Ten healthy single-rooted mandibular premolars that had been extracted for orthodontic purposes were selected for the study. Under copious water coolant, four radicular dentin sticks were obtained from each root by a precision diamond saw. One stick from each tooth was assigned to one of the four experimental irrigants:

Group 1 (Control): Saline
Group 2: 17% Ethylenediaminetetraacetic acid (EDTA)
Group 3: 0.2% Chitosan (Ch)
Group 4: 2% Chlorhexidine plus 10% Citric acid (CA-CHX)

In Group 3, for the preparation of 0.2% chitosan solution, 0.2 g of chitosan with 90% degree of deacetylation was diluted with 100 mL of 1% acetic acid in 100 mL of distilled water and the mixture was stirred for 2 h using a magnetic stirrer. In Group 4, 2% CHX was mixed directly with 10% CA. Each stick was immersed separately in 1 mL of the irrigant solution in a sealed plastic tube and placed in an ultrasonic vibrator for 5 min. Then the stick was rinsed with deionized water and then tested immediately for flexural strength under universal testing machine.

**Statistical Analysis**

Data were collected by using a structured proforma. Data were entered in MS excel and analyzed by using Statistical Package for the Social Sciences (SPSS) software (version 16). Quantitative data were expressed in terms of Means and Standard deviation. Data were analyzed using one-way ANOVA followed by Tukey's post hoc test. The significance level was set at $p < 0.01$ within all tests.

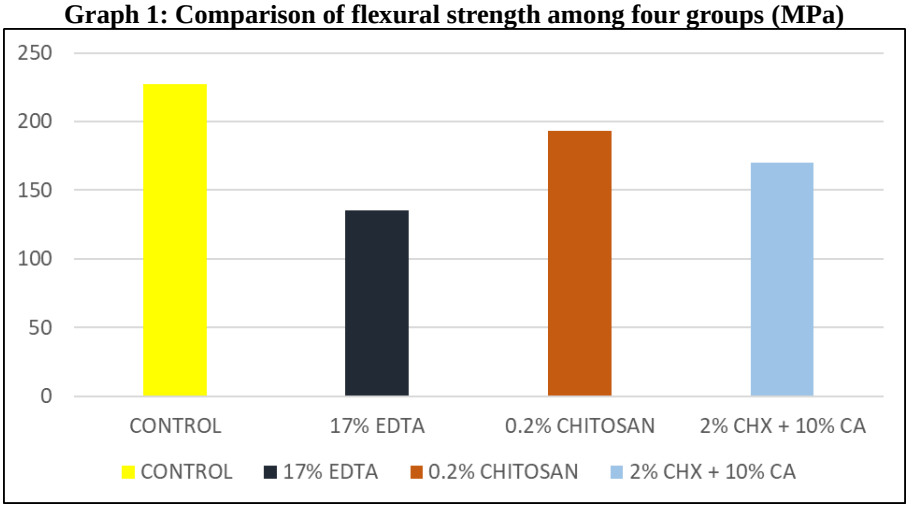
## III. Results

This in-vitro study evaluated and compared flexural strength of human radicular dentin sticks after conditioning with four different endodontic chelating agent : Normal saline, EDTA, Chitosan, Citric acid plus Chlorhexidine. Results for flexural strength of various group samples are presented in Table 1. Chitosan group demonstrated highest and statistically significant flexural strength followed by CA-CHX and EDTA. Both Chitosan and CA + CHX rinse did not significantly reduce the flexural strength of the radicular dentin when compared to the control group. EDTA group revealed the least values of flexural strength of radicular dentin and the difference as compared to all the other groups was statistically significant ($P < 0.001$).

**Table 1. Mean and standard deviations values for flexural strength (MPa) of each group are summarized in the table below:**

| Groups | Mean | SD | p - value | t - value |
|---|---|---|---|---|
| **Control** | 227 | 45.71 | <0.001 | 1.87 |
| **17% EDTA** | 135 | 24.15 | <0.001 | 5.50 |
| **0.2% Chitosan** | 193 | 26.74 | <0.001 | 1.97 |
| **10%Ca+2% CHX** | 170 | 25.81 | <0.001 | 3.33 |

**Graph 1: Comparison of flexural strength among four groups (MPa)**




## IV. Discussion

The chemical and structural composition of human dentin can be altered by root canal treatment, along with the various irrigants involved.[21] EDTA, even though is a frequently used dentinal chelator, it's detrimental effects on mechanical properties of root dentin, particularly the flexural strength, potentially outweigh its use extensive use.[22,23]. To control the variability of results, every four radicular dentin sticks were acquired from the same root for evaluating flexural strength. Each of these sticks was assigned to one of the different experimental chelators tested and then compared to the control (saline).

Adsorption, ionic exchange and chelation are probably the mechanisms responsible for the formation of complexes between chitosan and metal ions.[24,25] **Antunes et al. (2020)**[26] reported that 0.2% of chitosan on the dentin surface removes the smear layer and unblocks the dentinal tubules with a small amount of erosion of peritubular dentin. **Mathew et al. (2017)**[27] reported that Chitosan is an effective chelating agent with less alteration in root dentin and can be considered as a less invasive replacement to 17% EDTA.[21] This may explain why chitosan treated samples in this study showed the highest values of flexural strength than CA-CHX and EDTA with the difference being statistically significant. Also Chitosan group showed the least reduction in the flexural strength than other groups when compared to the control.

The combination of CA and CHX provides a broad antimicrobial activity[28] and smear layer removal capability.[29] As a result, this mixture may simplify irrigation procedures and decrease tissue toxicity. According to **Pashley, Michelich, and Kehl (1981)[30],** citric acid had a greater potential to remove calcium ions, in comparison with EDTA. **Scelza et al. (2003)[31]** found that the demineralizing action of 10% citric acid significantly increased from 3 to 10 min. This may explain why CA-CHX treated samples, in this study, showed the second highest values of flexural strength, statistically greater than EDTA group. However the reduction in the flexural strength of CA-CHX was not statistically significant when compared to the control.

EDTA caused a significant drop in its flexural strength of radicular dentin sticks as compared to the control.[32] This could be attributed to the decalcifying influence of EDTA on the mineral content of dentin mainly in the calcium-to-phosphorus ratio, owing to the consequent extraction of calcium ion from mineralized dental tissues resulting in a weaker substrate, thus predisposing endodontically treated teeth to root fracture.[33].

This study's results are in agreement with **Nassar et al. (2021)[34]** and **Baruwa et al. (2022)[35],** in which it was noted that EDTA can cause depletion of calcium cations from the surface of radicular dentin to a depth of almost 150 um.

## V. Conclusion

Considering the limitations of this study, it can be concluded that both 0.2% Chitosan and 10% Citric acid plus 2% Chlorhexidine chelators do not compromise the surface and bulk mechanical properties of radicular dentin.

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