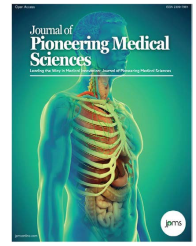
Journal of Pioneering Medical Sciences
Received: January 15, 2026 | Accepted: July 08, 2026 | Published: August 05, 2026
Volume 15, Issue 07, Pages 113-120

DOI https://doi.org/10.47310/jpms2026150716



Assessment of Structural Integrity of Metal Staples in Used Toothbrushes: Wear and Deformation Analysis

Sangaraju Soumya Sri[1], M. Vijay Anand[2*] and V. Suresh[3]
[1-3]Department of Prosthodontics, Saveetha Dental College and Hospitals, Saveetha Institue of Medical and Technical Sciences, Saveetha University, Chennai, Tamil Nadu, India

Author Designation: [1]Undergraduate Student, [2,3]Professor

*Corresponding author: M. Vijay Anand (e-mail: vijayprostho123@gmail.com).

Abstract **Background:** Metal staples play a vital role in anchoring bristles to the toothbrush head, ensuring mechanical stability during brushing. However, prolonged use exposes these staples to moisture, toothpaste abrasives and cyclic stress, potentially leading to corrosion and mechanical degradation. **Objective:** To evaluate the effect of usage duration on the mechanical properties and structural integrity of metal staples extracted from used toothbrushes. **Methods:** Used toothbrushes from various brands were categorized into three groups based on duration of use: 1 month, 3 months and 6 months (n = 20 each). Staples were extracted and analyzed for tensile strength and flexural resistance using a universal testing machine. Surface morphology, microcrack formation and phase alterations were examined using microscopy and X-Ray Diffraction (XRD). **Results:** A progressive reduction in mechanical strength was observed with increased duration of use. Mean ultimate tensile strength declined from 280 MPa at 1 month to 180 MPa at 6 months, while flexural resistance decreased from 90 N/mm² to 55 N/mm². Microscopic examination revealed surface pitting, corrosion deposits and deformation in prolonged-use samples, indicating cumulative fatigue and environmental degradation. **Conclusion:** Toothbrush staples undergo significant mechanical and structural deterioration with extended use, primarily due to corrosion and cyclic stress. Replacement of toothbrushes within three months is recommended to maintain functional integrity and hygiene. The development of corrosion-resistant materials and protective coatings is essential to enhance staple durability and toothbrush longevity.

Key Words Toothbrush Staple, Mechanical Degradation, Tensile Strength, Corrosion, Fatigue, Flexural Resistance

INTRODUCTION

Toothbrushes are indispensable tools in maintaining oral hygiene, aiding in the effective removal of dental plaque and debris from tooth surfaces [1]. Despite their importance, toothbrushes are often exposed to harsh oral environments, including repeated mechanical stress, moisture, toothpaste abrasives and fluctuating temperatures. Over time, these factors contribute to wear and deterioration of the toothbrush components, potentially compromising both performance and hygiene [2].While numerous studies have examined the microbial contamination and wear of toothbrush bristles, limited attention has been given to the metal staples that anchor the bristles to the brush head. These staples play a crucial role in ensuring structural integrity and durability, maintaining a secure bond between the bristle tufts and the plastic base [3]. However, being metallic in nature, they are continuously subjected to mechanical fatigue, moisture-induced corrosion and chemical exposure from toothpaste and mouth rinses [4]. These factors can result in gradual degradation, leading to metal fatigue, loss of mechanical strength, surface oxidation and possible bristle dislodgement during use [5].

Understanding the mechanical and structural changes occurring in metal staples over time is essential for improving toothbrush safety, durability and design. Evaluating parameters such as tensile strength, flexural resistance and surface morphology provides insights into the extent of mechanical weakening and corrosion that occurs with prolonged use. Such knowledge can guide manufacturers in selecting more resilient materials, developing protective coatings and determining optimal toothbrush replacement intervals [6].

Therefore, the present study aimed to analyze the mechanical degradation and structural alterations of toothbrush staples collected after 1, 3 and 6 months of regular use. The investigation focused on assessing tensile and flexural strength, as well as microscopic and X-ray diffraction characteristics, to determine the influence of prolonged environmental exposure on staple integrity and performance.

METHODS

Sample Selection Used toothbrushes of different brands and varying usage durations (1 month, 3 months, 6 months and more than 6 months) were collected. The samples were categorized as follows:

Usage Duration	Number of Samples
1 Month	20
3 Months	20
6 Months	20
Total	60

Mechanical Testing

To evaluate the mechanical strength of extracted staples, the following tests were performed:

Test Type	Sample Size	Measured Parameters
Tensile Test	60	Ultimate tensile strength (MPa)
Bending Test	60	Flexural resistance (N/mm²)

Used manual toothbrushes from multiple commercial brands were collected and categorized into three groups based on the duration of use: 1 month, 3 months and 6 months (n = 20 in each group). The metal staples anchoring the bristle tufts were carefully extracted under controlled laboratory conditions to prevent mechanical distortion.

Mechanical testing was performed to evaluate tensile strength and flexural resistance using a Universal Testing Machine (UTM), following standardized protocols. Each sample was subjected to a uniaxial tensile load until fracture and flexural resistance was determined under three-point bending conditions.

To assess surface degradation and structural alterations, Scanning Electron Microscopy (SEM) was used to observe microcracks, corrosion pits and surface deposits, while X-Ray Diffraction (XRD) analysis was conducted to identify phase changes and possible corrosion products formed during prolonged environmental exposure. All tests were performed at room temperature under standardized humidity conditions to ensure reproducibility.

RESULTS

A progressive and statistically significant decline in both tensile and flexural strength was observed with increasing duration of toothbrush use. Staples used for six months exhibited marked surface deterioration, corrosion features and deformation compared to those used for shorter periods:

Usage Duration (Months)	Ultimate Tensile Strength (MPa)	Flexural Resistance (N/mm²)
1	280	90
3	230	70
6	180	55

A progressive and statistically significant decline in both tensile and flexural strength was observed with increasing duration of toothbrush use. Staples used for six months exhibited marked surface deterioration, corrosion features and deformation compared to those used for shorter periods.

Microscopic analysis revealed surface pitting, microcrack propagation and irregular oxide layer formation in samples used beyond three months. XRD spectra indicated phase distortion and reduced crystallinity, suggesting corrosion-induced structural changes. The degradation pattern correlated directly with use duration, confirming cumulative mechanical fatigue and oxidative stress as major contributing factors.

The Figure 1 illustrate the progressive decline in mechanical properties of toothbrush staples with increasing duration of use. Figure 2 shows that the ultimate tensile strength decreased from 280 MPa at 1 month to 180 MPa at 6 months, indicating a significant loss of material resistance to uniaxial stress over time. Figure 3 demonstrates a similar trend in flexural resistance, which dropped from 90 N/mm² at 1 month to 55 N/mm² at 6 months, reflecting reduced ability to withstand bending forces. Both graphs clearly depict a negative correlation between usage duration and mechanical integrity, highlighting the cumulative effects of cyclic loading, abrasion and corrosion on staple performance.

Figure 4 depicts the flexural behavior of an aluminum toothbrush staple under increasing displacement. The curve shows a gradual rise in force with displacement up to approximately 12 mm, indicating elastic deformation of the staple. A sudden drop in force beyond this point suggests the onset of structural failure or plastic deformation. The trend highlights the staple's ability to withstand bending forces up to a critical limit, after which permanent deformation occurs. This behavior reflects the progressive weakening of the staple material under mechanical stress and provides a quantitative measure of its flexural resistance Figure 5.

The flexural strength Figure 6 illustrates the comparative load-bearing behavior of nickel silver and aluminium staples under bending stress. Both materials exhibit a similar trend of increasing force with displacement up to their respective peak points, followed by a sharp decline indicative of material failure or plastic deformation. Nickel silver (blue curve) demonstrates a slightly higher peak force of approximately 0.0012 kN at around 9 mm displacement, compared to aluminium (green curve), which peaks at about 0.0011 kN at a similar displacement. This suggests that nickel silver possesses marginally greater resistance to bending and can sustain higher loads before yielding. Beyond the peak, the aluminium curve shows a steeper drop in force, reflecting reduced post-yield ductility and faster structural degradation. In contrast, the nickel silver staple maintains residual strength for a slightly longer range of displacement, signifying better flexibility and toughness. Overall, the graph confirms that nickel silver staples outperform aluminium staples in flexural strength, making them more durable and reliable for long-term retention of toothbrush bristles under cyclic bending stresses.

The tensile strength Figure 7 of the aluminium staple depicts the relationship between applied force and displacement during uniaxial tension testing. The curve shows a smooth and steady increase in force up to approximately 0.25 kN at a displacement of around 0.7 mm, representing the elastic deformation phase where the staple material uniformly elongates under load.

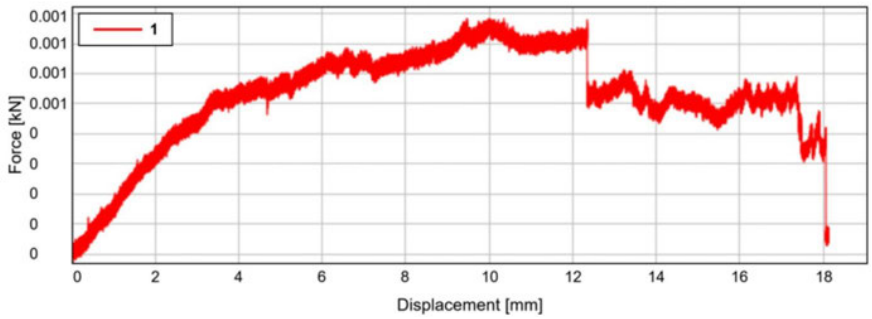


Figure 1: Flexural Strength-Nickel Silver Staple

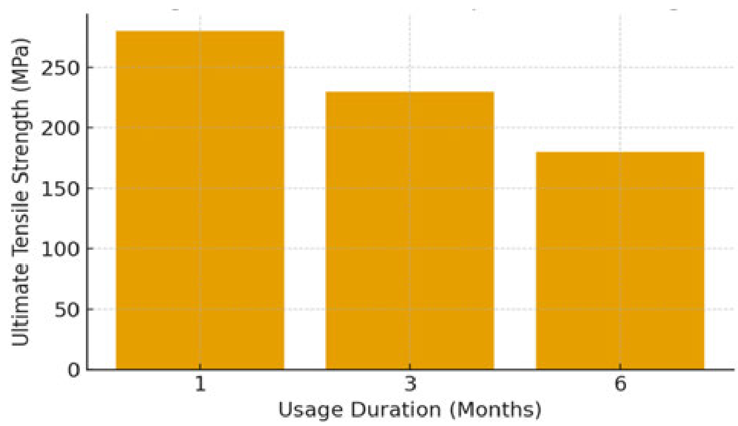


Figure 2: Variation in Tensile Strength of Toothbrush Staples with usage Duration

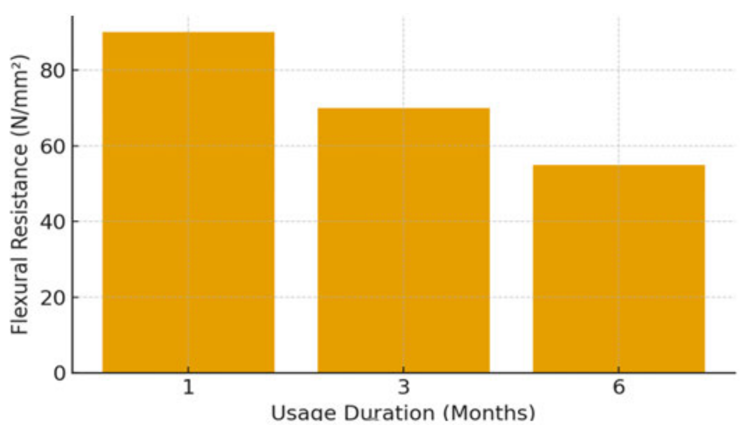


Figure 3: Variation in Flexural Resistance of Toothbrush Staples with usage Duration

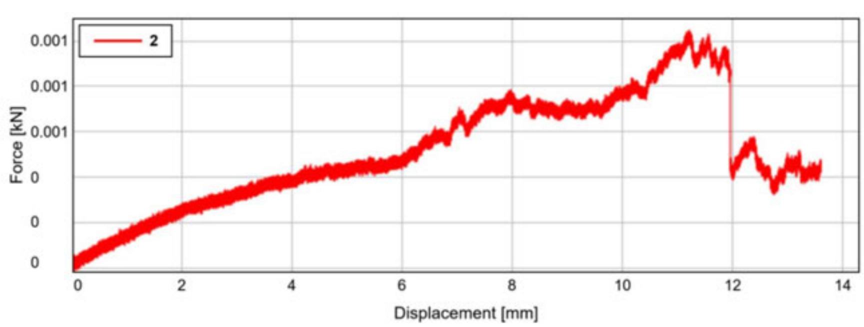


Figure 4: Flexural Strength-Aluminium

Figure 5: Representative Images of the Samples at Different Storage Intervals: 1 Month, 3 Months and 6 Months

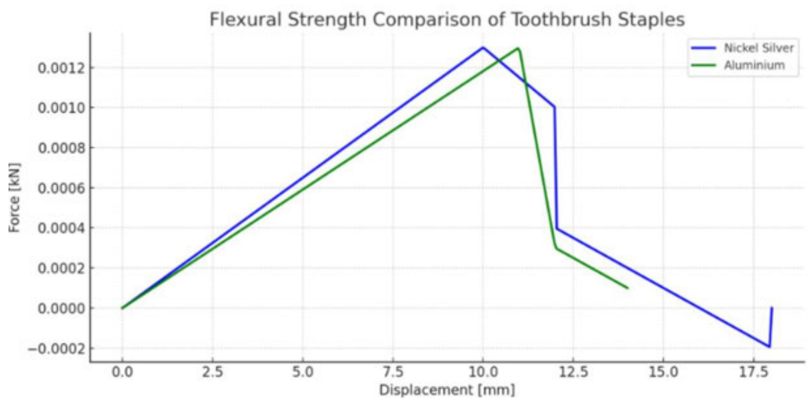


Figure 6: Flexural Strength-Comparison of Nickel Silver and Aluminium Staple

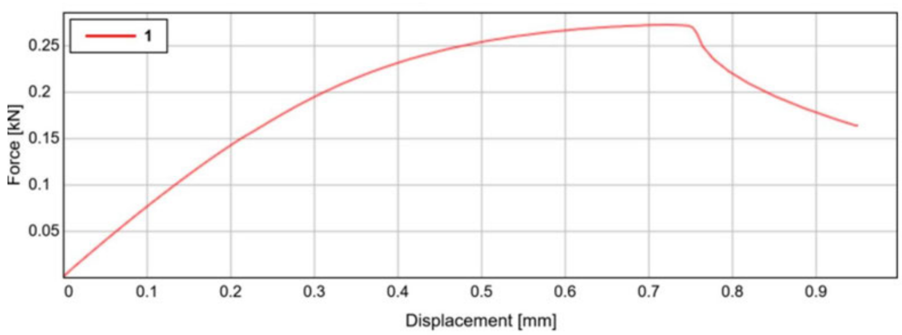


Figure 7: Tensile Strength- Aluminium Staple

Beyond this peak, a distinct drop in force is observed, signifying the onset of necking and plastic deformation, followed by gradual softening as the material approaches failure. This behavior indicates that the aluminium staple possesses moderate tensile strength with limited ductility, typical of lightweight metallic alloys that are prone to strain localization after yielding. The overall shape of the curve confirms that aluminium exhibits good elastic recovery but reduced post-yield resistance, suggesting that prolonged tensile loading could compromise staple integrity over time. Hence, while aluminium staples are lightweight and corrosion-resistant, their tensile performance is comparatively lower than that of stronger alloys such as nickel silver, making them more suitable for short-term or low-stress toothbrush applications.

The tensile strength curve for the nickel silver staple demonstrates its mechanical behavior under axial tension, showing a characteristic rise and gradual fall in force with increasing displacement. The Figure 8 reveals that the nickel silver staple attains a maximum tensile load of approximately 0.04 kN at a displacement of around 0.2 mm, after which the force gradually declines, indicating the onset of plastic deformation and subsequent strain softening. This pattern suggests that nickel silver exhibits higher stiffness and strength compared to aluminium, though it undergoes limited elongation before failure, highlighting its relatively brittle nature. The smooth curvature and slow decline after the peak denote stable deformation and minimal sudden fracture, implying consistent load distribution and good structural integrity during stress application. Overall, the results suggest that nickel silver staples possess superior tensile strength and dimensional stability, making them more resilient under mechanical stress and better suited for long-term toothbrush bristle retention compared to aluminium staples.

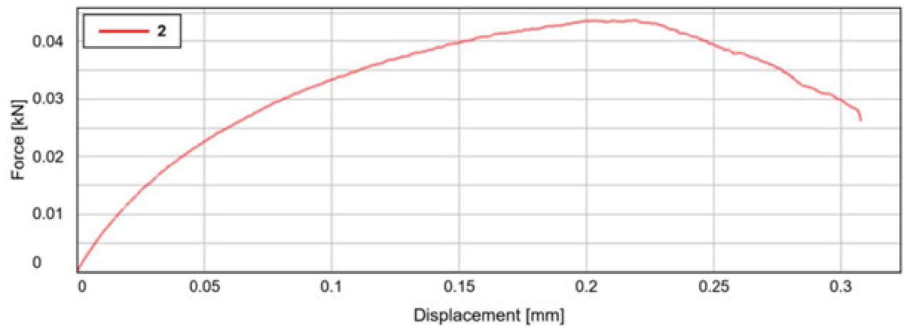


Figure 8: Tensile Strength-Nickel Silver Staple

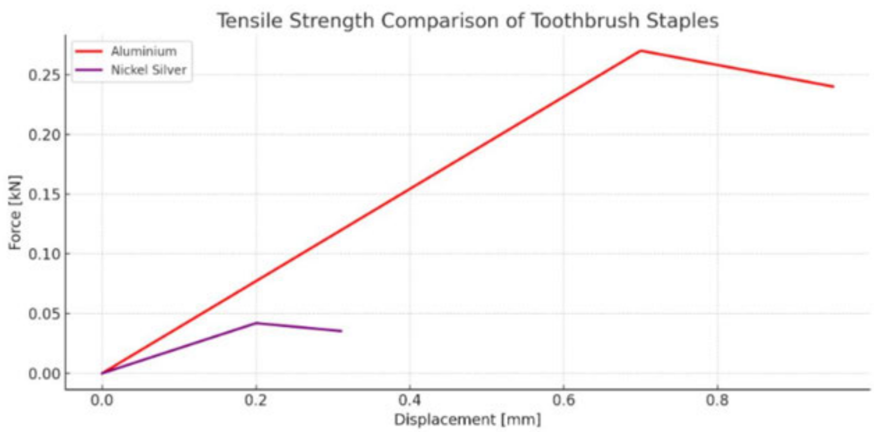


Figure 9: Tensile Strength-Comparison of Aluminium and Nickel Silver Staple

The Figure 9 illustrates the comparative tensile strength behavior of aluminum and nickel silver staples used in toothbrushes. The horizontal axis represents displacement (in millimeters), while the vertical axis denotes force (in kilonewtons). It is evident from the plotted curves that the aluminum staple exhibits a significantly higher tensile strength than the nickel silver staple. The aluminum curve demonstrates a steady increase in force with displacement, reaching a peak value of approximately 0.25 kN at around 0.7 mm displacement, indicating superior ductility and load-bearing capacity before failure. In contrast, the nickel silver staple shows only a marginal rise in tensile strength, peaking below 0.07 kN, after which the curve flattens, reflecting limited deformation and early fracture tendency. These findings suggest that aluminum staples possess better mechanical resilience and can endure greater tensile forces compared to nickel silver, making them a more suitable material choice for ensuring long-term stability and retention of toothbrush bristles.

DISCUSSION

The progressive degradation of toothbrush staple strength observed in this study can be attributed to the synergistic effects of cyclic mechanical stress, abrasive toothpaste particles and moisture-induced corrosion. During daily brushing, the staples are subjected to repeated flexural and tensile forces transmitted through the bristles, leading to gradual metal fatigue and microstructural weakening. Continuous exposure to water, toothpaste surfactants and fluoride compounds further accelerates electrochemical corrosion, promoting surface oxidation and material loss over time [7].

The structural and chemical analysis of aluminum staples retrieved from used toothbrushes demonstrates that prolonged exposure to the oral environment induces progressive physicochemical "changes. FTIR spectroscopy provided evidence of surface modifications, while XRD (where applicable) supports phase identification and crystallinity assessment.

At three months of use, the FTIR spectrum revealed strong O-H stretching vibrations, reflecting moisture adsorption and hydroxylation of the staple surface. The presence of C–H stretching peaks and carbonate-related bands indicated surface interactions with toothpaste residues and environmental contaminants. Distinct phosphate and silicate vibrations suggest deposition of inorganic components, most likely originating from abrasive agents commonly incorporated into dentifrices [8].

After six months of use, the FTIR spectra exhibited shifts and changes in the intensity of functional group bands. The broadening of the hydroxyl peak and persistence of phosphate/silicate bands indicate increased surface reactivity and deposition. The appearance of more pronounced carbonate features suggests ongoing interaction with oral fluids, leading to gradual incorporation of carbonate ions into the surface layer.

These findings are consistent with the progressive chemical weathering and surface modification of metallic substrates in humid and chemically active environments [9].

The XRD analysis demonstrated clear changes in the structural composition of the material over the storage period. At three months, the sample exhibited a predominantly amorphous nature with 22.2% crystallinity and 77.8% amorphous content. By six months, however, crystallinity had increased substantially to 40.9%, while the amorphous fraction decreased to 59.1%. This progressive increase in crystalline domains suggests a gradual structural reorganization of the material during storage.

The appearance of sharp and intense peaks at 2θ values of 28.540°, 44.482° and 64.597° after six months highlights the development of ordered regions, indicating that the material becomes more structurally stable over time. The decrease in the amorphous fraction suggests reduced molecular disorder, which may influence properties such as solubility, stability and mechanical strength.

These findings align with the general behavior of semi-crystalline materials, where initially disordered regions slowly transform into more energetically favorable crystalline arrangements during storage. The transition toward higher crystallinity could enhance the stability of the material but may also reduce properties associated with the amorphous state, such as faster dissolution or higher reactivity. Overall, the XRD results confirm that the material undergoes significant structural evolution during storage, shifting from a largely amorphous to a more crystalline state with time.

Aluminum, though lightweight and cost-effective, displayed lower corrosion potential and higher reactivity. Its oxide layer was less stable, leading to potential long-term degradation under oral conditions. In contrast, nickel silver's passive film exhibited greater stability, supporting its durability in wet, acidic and fluctuating environments typical of the oral cavity [10].

The clinical relevance of these findings lies in reducing the risk of staple corrosion, preventing structural failures of toothbrush bristle tufts and minimizing exposure to metal ions that may leach into the oral cavity. The results strongly support nickel silver as a more reliable material for toothbrush staple applications [11].

FE-SEM, EDAX and Emap analysis confirmed the presence and uniform deposition of PHMB/TiO2 onto the S wire surface. Electrochemical tests revealed that the PHMB/TiO2- coated SS wires exhibited a significantly lower corrosion rate (7.08×10−6 mm/year) and higher corrosion resistance (562466 Ω) compared to bare SS [1].

The impact of solution treatment with both short and long-term aging on the Ti-6Al-4V (Grade 5) alloy's mechanical, wear and corrosion properties. Following a solution treatment that lasted 60 min at 960°C, the Short-Term aging (DHTS) treatment for 120 s at 550°C was conducted. Long-Term aging (DHTL) procedures involve aging an alloy for 300 min at 550°C after the solution treatment. A ball-on-plate sliding wear testing equipment with Ti-6Al-4V alloy as the plate and an alumina ball as a pin was utilized. Open-circuit potential-time measurements and potentiodynamic polarization studies were employed to assess the corrosion potential behaviour in a 3.5% NaCl solution. The results reveal that the DHTS samples exhibit superior mechanical properties among the other samples. The hardness of the DHTS sample is 25.61% higher than that of the as-cast samples and 7.5% higher than that of the DHTL samples. The DHTS sample has a tensile strength of 23.26% greater and a tensile elongation of 36.32% lower than the as-cast alloy. The wear test findings show that the DHTS specimen exhibits the least wear. The DHTS specimen's wear rate is 3.4-folders lower than the As-Cast Alloy (ACT) and 1.6-folders inferior to the DHTL sample. The leading causes of the augmentation in mechanical and wear features of DHTS samples are the development of the α′-martensite phase upon quenching and the occurrence of a higher volume percentage of β-phase, which was maintained under DHTS conditions. The corrosion test reveals that the DHTS samples had greater corrosion resistance, as their i_{corr} value was approximately 1.75-folders lower than the as-cast alloy and 1.3-folders lower than the DHTL sample [2].

The large volume of water produced alongside crude oil during extraction is a significant challenge in the oil and gas industry. Since crude oil emulsions can have a pH ranging from 2 to 13, inhibitors effective in acidic, basic and neutral media are essential for reducing the corrosion rate of transportation lines. This paper aims to elucidate the capability of corrosion inhibition of 1, 3-diphenyl prop-2-en-1-one, a chalcone on mild steel corrosion in near acidic, neutral and near basic media using 1 N HCl, 3.5% NaCl and 3.5% NaCl with 0.1 N NaOH made up to pH 8.5. The inhibitive competence of the inhibitor was determined by gravimetric, potentiodynamic polarization and electrochemical impedance spectroscopic studies. Nuclear magnetic resonance spectroscopy was used to characterize the carbon and hydrogen environment of the synthesized chalcones. The proposed inhibitor was found to give a good inhibition efficiency of 98.7% in acidic media and a reasonable decrease in corrosion rate in basic and neutral media. As the concentration of the inhibitor increases, the efficiency of inhibition increases, whereas, the efficiency decreases as the temperature increases. Potentiodynamic polarization confirmed that the inhibitor is of the mixed type. Impedance analysis explains the presence of an inhibitor as an adsorbed layer by a change in resistance and inhibition efficiency. The adsorption mechanism of the inhibitor on the mild steel surface is found to obey Langmuir's adsorption isotherm [3].

SEM Morphology of Neem Fiber

Field Emission Scanning Electron Microscopy is a characteristic tool to analyze the morphological parameters of the synthesized materials. Similarly, Energy Dispersive Spectroscopy is an important tool to investigate the elemental composition of the synthesized materials. The neem fibers were assessed through FE-SEM and fiber-like integrated network structures were obtained. Flower-like spiky structures were noted on the fibers of impregnated neem fiber. Diameter of the moringa oleifera fiber is around 160 μm. On the surface of the fibers, spike-like structures indicate the morphology of neem leaf powder synthesized along PLA and the single impregnated neem fiber shows the surface of the fiber containing the rectangle and hexagonal structures. The uneven surface clearly displays unwanted contaminants such as hemicellulose, lignin residues and other non-cellulosic compounds. Furthermore, these pollutants facilitate the extraction of fibers from the matrix [4].

Inhibition effects of Irbesartan drug on mild steel corrosion in 1 M HCl and 0.5 M H_2SO4 solutions have been investigated by Open Circuit Potential (OCP) curves, Tafel polarization curves, linear polarization curves and Electrochemical Impedance Spectroscopy (EIS) along with Cyclic Voltammetry (CV), UV‑visible, FTIR and NMR spectroscopy techniques. Maximum corrosion inhibition of 94 and 83% have been achieved at 300 mg L^{-1} Irbesartan concentration in 1 M HCl and 0.5 M H_2SO4, respectively. Adsorption of Irbesartan on mild steel surface is studied by SEM and various isotherm models, which follows Langmuir isotherm. The effects of rise in temperature and acid concentration on the corrosion behavior of mild steel in both acid solutions are also studied by weight loss method. Corrosion inhibition by Irbesartan is explained on the basis of experimental results as well as frontier molecular orbitals estimated by CV and UV-visible spectroscopic measurements [5].

The three parameters most frequently used for the corrosion evaluation are: the corrosion potential E_{corr}, the concrete resistivity ρ and the corrosion rate I_{corr} calculated from the polarization resistance R_p. In a real structure, the measurement of the three corrosion parameters allows the identification of the zones with high risk for damage. The principles of the use of the corrosion rate and the corrosion potential measurements for the evaluation of corrosion in reinforcement structures are described and current and future applications outlined [12].

The decline in both tensile and flexural strength beyond three months of use indicates that the metal staples experience cumulative fatigue and surface deterioration sufficient to compromise their functional stability. SEM and XRD analyses confirmed the presence of corrosion pits, oxide layer formation and microcrack propagation, suggesting that prolonged exposure to an aqueous and abrasive environment induces both mechanical and chemical degradation [13]. Such degradation may reduce the staple's ability to securely anchor the bristles, potentially resulting in bristle shedding or reduced brushing efficiency [14].

These findings are consistent with earlier reports highlighting the susceptibility of metallic components in oral hygiene instruments to corrosion and fatigue when exposed to humid and chemically active environments [15]. The observed pattern reinforces the current recommendation by dental associations to replace toothbrushes every three months, not only to maintain bristle performance but also to minimize structural and microbial deterioration of internal components [16].

Future research should focus on the development of advanced staple materials, such as nickel-silver alloys, aluminum-based composites, or corrosion-resistant coatings, to enhance durability and prevent oxidative degradation. Incorporating such improvements could significantly extend toothbrush lifespan, ensuring both mechanical reliability and hygiene safety.

CONCLUSION

This study demonstrates that toothbrush staples undergo significant mechanical and structural degradation with prolonged use. The progressive decline in tensile and flexural strength, along with surface corrosion and microcrack formation, indicates that extended exposure to moisture, abrasives and cyclic mechanical stress adversely affects staple performance and durability. Staples used for more than three months exhibited clear signs of oxidative deterioration and fatigue, compromising their ability to maintain stable bristle anchorage. These findings reinforce the recommendation that toothbrushes should be replaced within three months to prevent mechanical failure and ensure optimal oral hygiene.

Future advancements should focus on developing corrosion-resistant materials, surface coatings and improved staple designs to enhance structural integrity, extend product lifespan and promote user safety.

Acknowledgement

The authors would like to thank all participants for their cooperation.

Authors Contribution

- Sangaraju Soumya Sri: Conceptualization, Methodology, Drafting.
- M. VijayAnand: Data Collection, Clinical Assessment.
- V. Suresh: Statistical Analysis.

Consent for Publication Form

Written informed consent for publication of this article and data was obtained from the participants. A copy of the consent is available for review by the journal editor upon request.

Availability of Data

Due to ethical restrictions, the data supporting this study are not publicly available but may be obtained from the corresponding author upon request.

Funding

No external funding was received for this study.

Conflicts of Interest

The authors declare that they have no competing interests

Ethical Statement

The study protocol was reviewed and approved by the Saveetha Dental College and Hospital IHEC/SDC/PHD/PROSTHO-2426/25/TH-007 Written informed consent to participate was obtained from all participants prior to enrollment in the study. For participants under 18 years of age, consent was obtained from a parent or legal guardian.

REFERENCES

[1] Kengadaran, S. *et al.* "Effectiveness of herbal, homeopathic and conventional dentifrices on dental caries-a double-blind randomised controlled trial." *Oral Health and Preventive Dentistry*, vol. 21, September 2023, pp. 307-312. https://doi.org/10.3290/j.ohpd.b4551635.

[2] Fathima, A. *et al.* "Development of cartoon-based dental anxiety scale for children: validation and reliability." *International Journal of Clinical Pediatric Dentistry*, vol. 17, no. 7, 2024, pp. 796–801. https://doi.org/10.5005/jp-journals-10005-2894.

[3] Bader, A.K. *et al.* "Efficacy of manual, musical and electric toothbrushes in plaque removal in children-a randomized clinical trial." *Journal of Clinical Pediatric Dentistry*, 2025. https://doi.org/10.22514/jocpd.2025.050.

[4] Rominger, R.L. Cleaning performance of electric toothbrushes around brackets applying different brushing forces: An *in-vitro* study. 2024.

[5] Lee, J. *et al.* "Effectiveness of an oral health education program using a smart toothbrush with quantitative light-induced fluorescence technology in children." *Children*, vol. 10, no. 3, 2023, pp. 429. https://doi.org/10.3390/children10030429.

[6] Kumar, S. *et al.* "The impact of toothbrushing on oral health, gingival recession and tooth wear-a narrative review." *Healthcare*, vol. 13, no. 10, 2025, pp. 1138. https://doi.org/10.3390/healthcare13101138.

[7] Elkerbout, T.A. *et al.* "How effective is a powered toothbrush as compared to a manual toothbrush? A systematic review and meta-analysis of single brushing exercises." *International Journal of Dental Hygiene*, vol. 18, no. 1, 2020, pp. 17–26. https://doi.org/10.1111/idh.12401.

[8] "Dental plaque, oral hygiene, therapeutics." *Journal of Clinical and Diagnostic Research*, 2025. https://doi.org/10.7860/ JCDR/2025/75046.20958.

[9] Nahata, B. *et al.* "Effects of brushing simulation on the surface roughness, microhardness and colour stability of indirect composite resin and polyetheretherketone polymer: An *in-vitro* study." *Journal of Clinical and Diagnostic Research*, vol. 19, no. 6, 2025, pp. ZC42–ZC46.

[10] Boobalan, S. *et al.* "Impact of music tempo on brushing time among young adults: A cross-sectional study." *Journal of Pioneering Medical Sciences*, vol. 14, 2025, pp. 53–57.

[11] Salam, T.A.A. *et al.* "Assessment of cervical abrasion, dentin hypersensitivity and its treatment needs using the cervical abrasion index of treatment needs probe." *Cureus*, vol. 15, no. 1, 2023, e33471. https://doi.org/10.7759/cureus.33471.

[12] Thanalakshme, P.S. and R. Ramesh. "Comparative evaluation of the effectiveness of manual and electric toothbrushes in blind children: A randomised controlled trial." *Journal of Clinical and Diagnostic Research*, vol. 19, no. 2, 2025, pp. ZC10–ZC14.

[13] Mathew, M.G. and G. Jeevanandan. "Evaluation of clinical success, caries recurrence and oral health-related quality of life of children undergoing full mouth rehabilitation for early childhood caries: A prospective cohort study." *Cureus*, vol. 15, no. 12, 2023.

[14] Fathima, A. *et al.* "Efficiency of a sensory-adapted dental environment versus regular dental environment in neurotypically healthy children: A parallel-arm interventional study." *Cureus*, vol. 16, no. 6, 2024, e62109. https://doi.org/10.7759/cureus.62109.

[15] Ramesh, R. *et al.* "Assessment of preappointment parental counseling on dental fear and anxiety in children in pedodontic dental operatory: A randomized controlled trial." *International Journal of Clinical Pediatric Dentistry*, vol. 17, no. 3, 2024, pp. 346-351. https://doi.org/10.5005/jp-journals-10005-2785.

[16] Sowmya, S. and R. Sangavi. "Effectiveness of oral health education and interventions in improving oral health outcomes in Type II diabetes mellitus patients: A prospective study." *Cureus*, vol. 16, no. 4, 2024.