

SCANNING ELECTRON MICROSCOPIC (SEM) COMPARISON OF SURFACE PROPERTIES OF NITI WIRE AND STAINLESS-STEEL WIRE

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ABSTRACT

Orthodontic archwires play a crucial role in tooth movement, and their surface characteristics significantly influence friction, corrosion resistance, and overall clinical performance. This study aims to evaluate and compare the surface properties of nickel-titanium (NiTi) wires and stainless steel (SS) wires using scanning electron microscopy (SEM).

SEM analysis was performed to assess surface morphology, irregularities, and roughness of both types of wires. The NiTi wires exhibited surface irregularities, porosities, and microstructural defects, whereas stainless steel wires demonstrated comparatively smoother surfaces with fewer imperfections.

The findings suggest that stainless steel wires have superior surface smoothness, which may contribute to reduced friction during orthodontic treatment. In contrast, NiTi wires, although exhibiting rougher surfaces, provide advantageous mechanical properties such as superelasticity and shape memory.

Thus, both materials possess unique advantages, and their selection should be based on clinical requirements.

KEYWORDS: NiTi wire, Stainless steel wire, SEM, Surface roughness, Orthodontics, Friction, Archwire

INTRODUCTION

Orthodontic treatment relies heavily on the use of archwires to deliver controlled forces for tooth movement. The efficiency of orthodontic wires depends not only on their mechanical properties but also on their surface characteristics [1]. Surface morphology plays a significant role in determining frictional resistance, corrosion behavior, and biocompatibility of orthodontic wires [2].

Nickel-titanium (NiTi) wires are widely used in orthodontics due to their unique properties, including superelasticity and shape memory effect [3]. These characteristics allow continuous and gentle force application, making them ideal for initial stages of orthodontic treatment [4]. However, NiTi wires are often associated with surface irregularities that may increase friction and plaque accumulation [5].

Stainless steel (SS) wires, on the other hand, are known for their high strength, stiffness, and corrosion resistance [6]. They exhibit relatively smoother surfaces, which reduce friction between the wire and bracket interface, thereby enhancing sliding mechanics during orthodontic treatment [7].

Surface roughness is a critical factor influencing frictional resistance. Increased roughness leads to higher friction, which may hinder tooth movement and prolong treatment duration [8]. Scanning electron microscopy (SEM) is a powerful tool used to analyze surface topography and detect microscopic irregularities in orthodontic wires [9].

Previous studies have demonstrated that manufacturing processes, environmental exposure, and intraoral conditions can alter the surface properties of orthodontic wires [10]. Therefore, understanding the surface characteristics of different archwires is essential for optimizing clinical performance.

The present study aims to compare the surface morphology of NiTi and stainless steel wires using SEM and evaluate their clinical implications in orthodontic treatment.

AIM

To compare the surface properties of nickel-titanium (NiTi) wire and stainless steel (SS) wire using scanning electron microscopy.

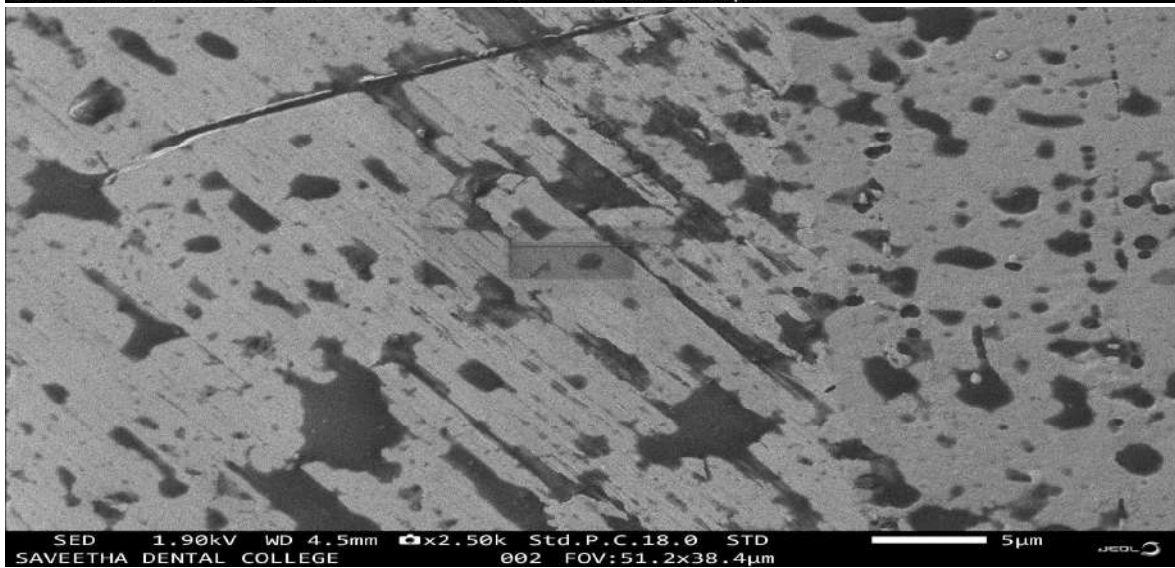
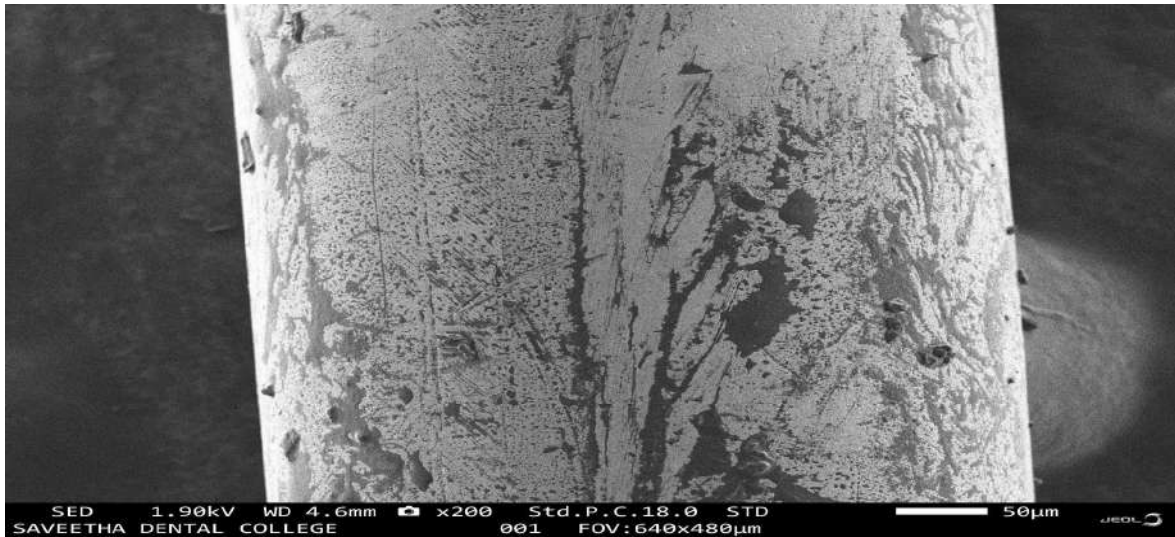
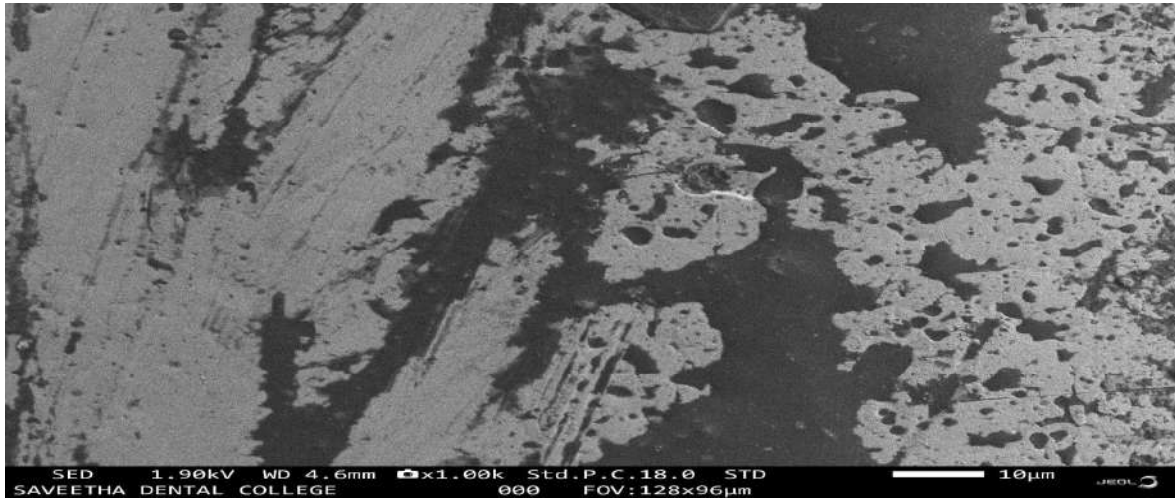
OBJECTIVES

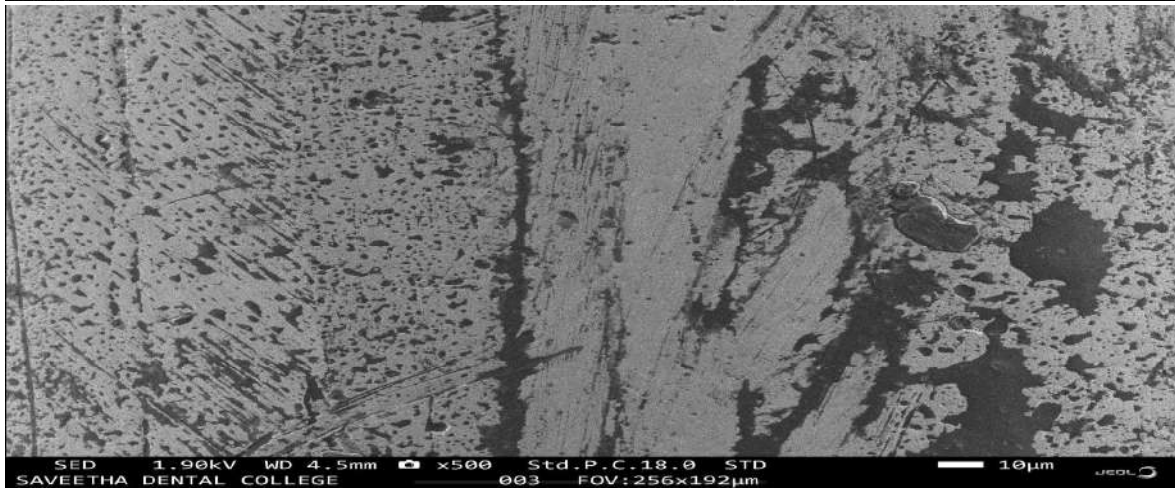
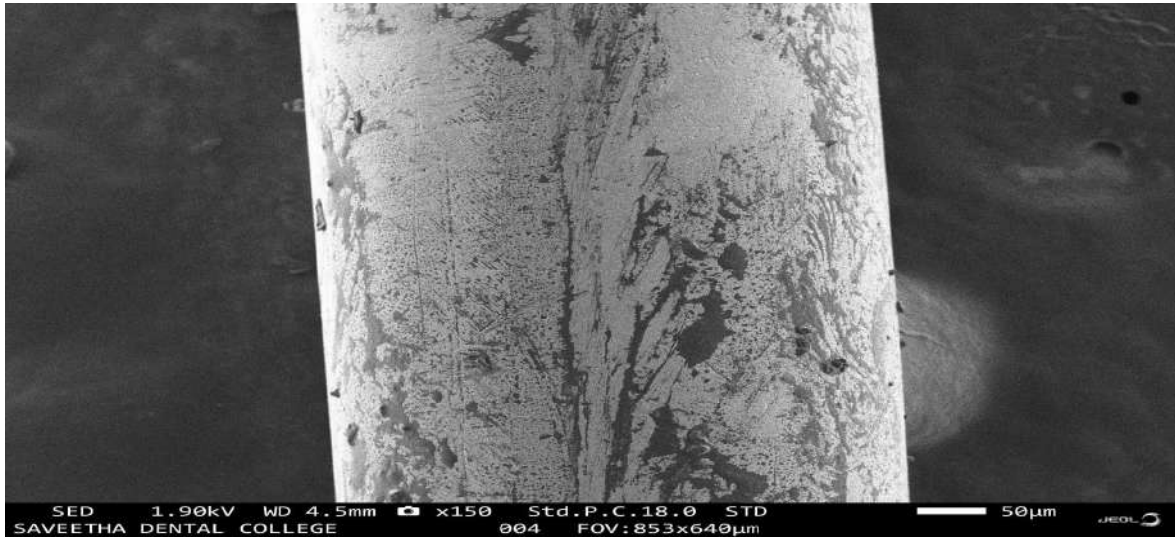
- To evaluate the surface morphology of NiTi wires using SEM
- To evaluate the surface morphology of stainless steel wires using SEM
- To compare surface roughness and irregularities between the two wires
- To analyze the clinical implications of surface characteristics
- To determine the suitability of each wire in orthodontic treatment

MATERIALS AND METHODS

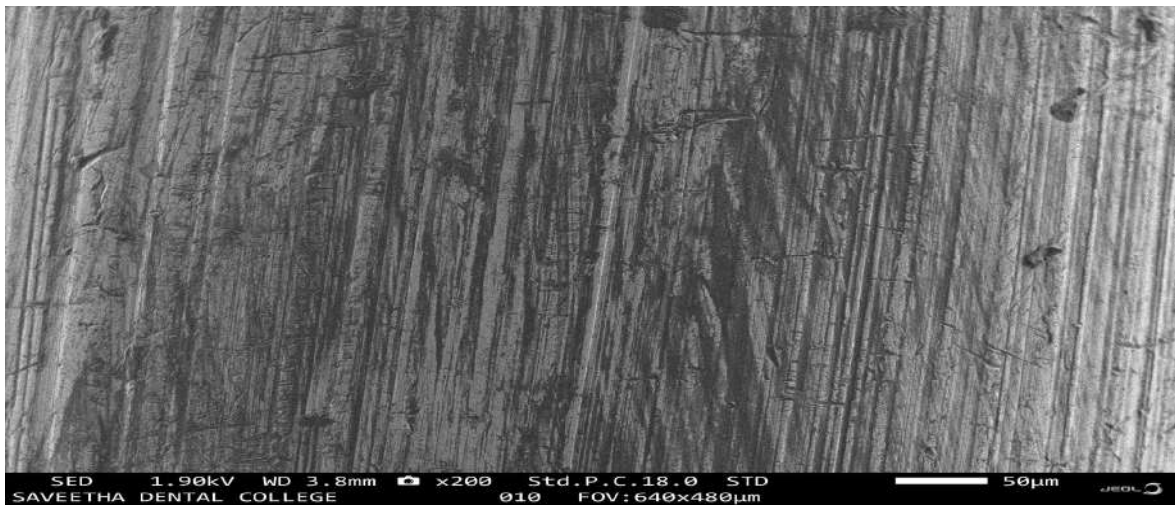
- Sample Selection: NiTi and stainless steel orthodontic wires
- Preparation: Samples cleaned and prepared for SEM analysis
- SEM Analysis: Surface morphology observed under scanning electron microscope
- Parameters Evaluated:
 - Surface roughness
 - Presence of pits, cracks, and irregularities
 - Surface uniformity

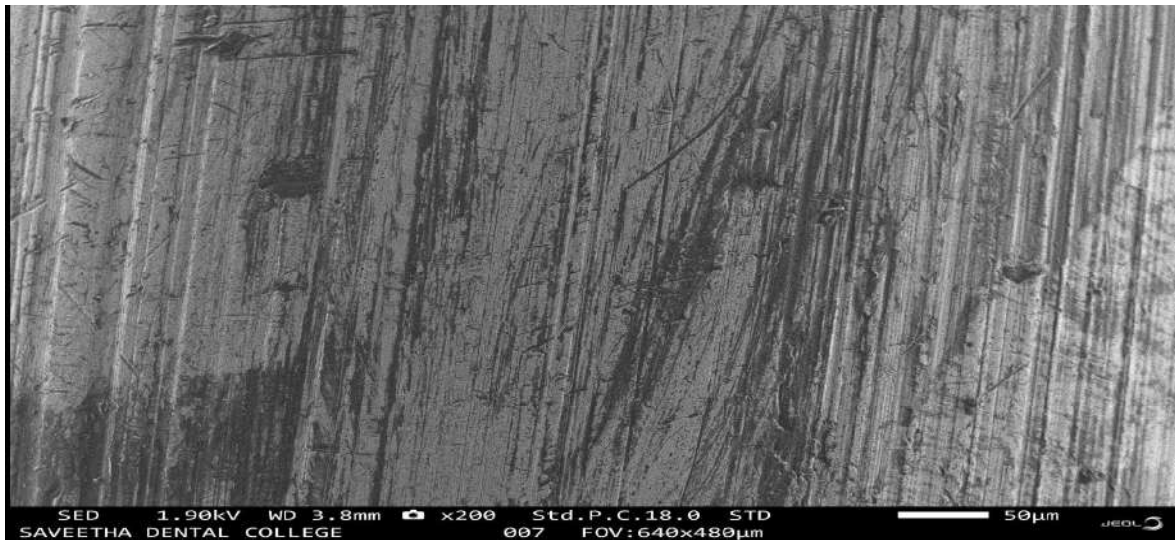
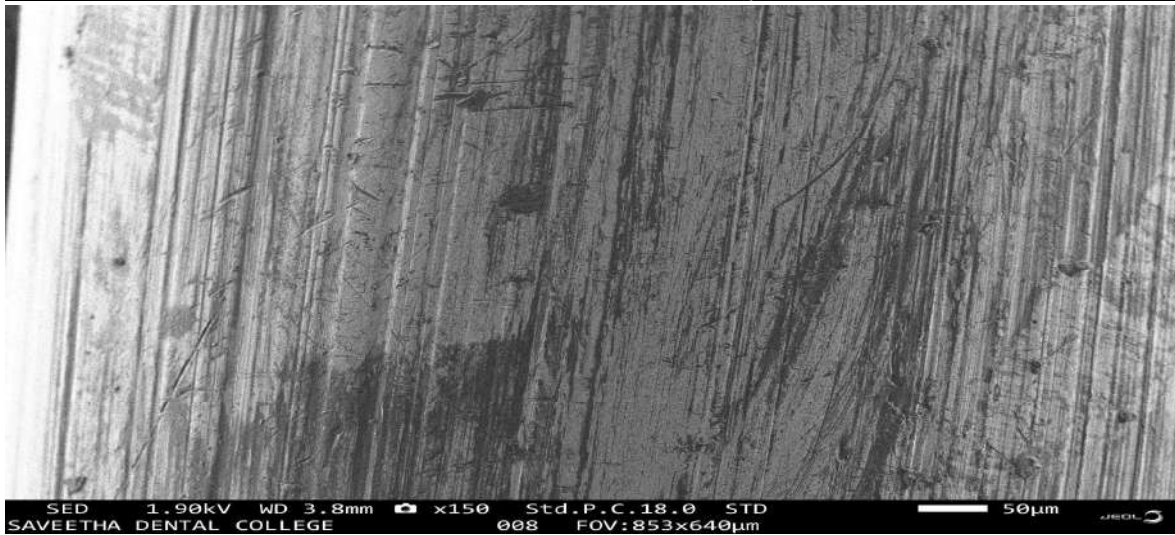
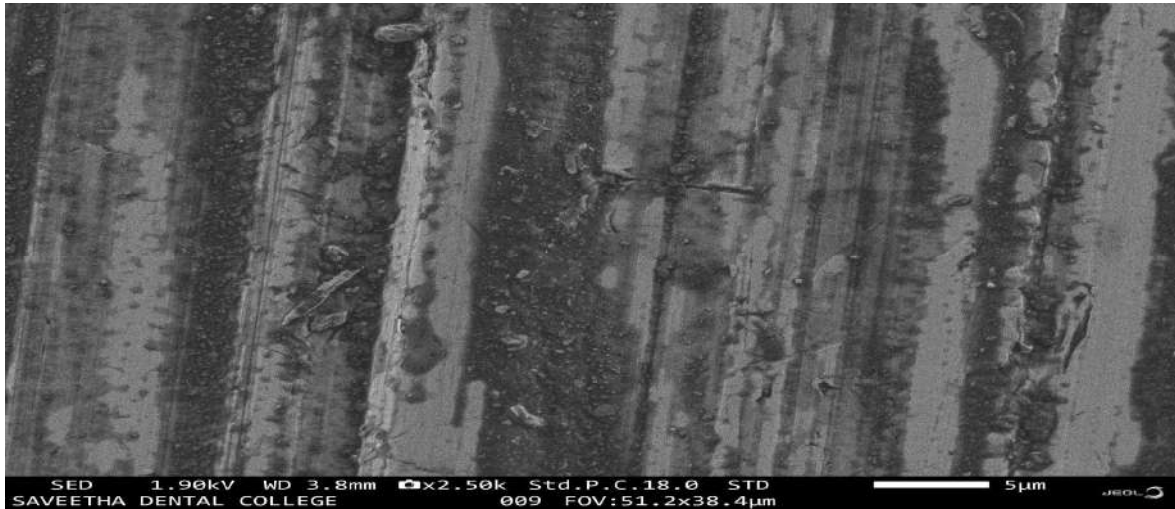
RESULTS AND DISCUSSION

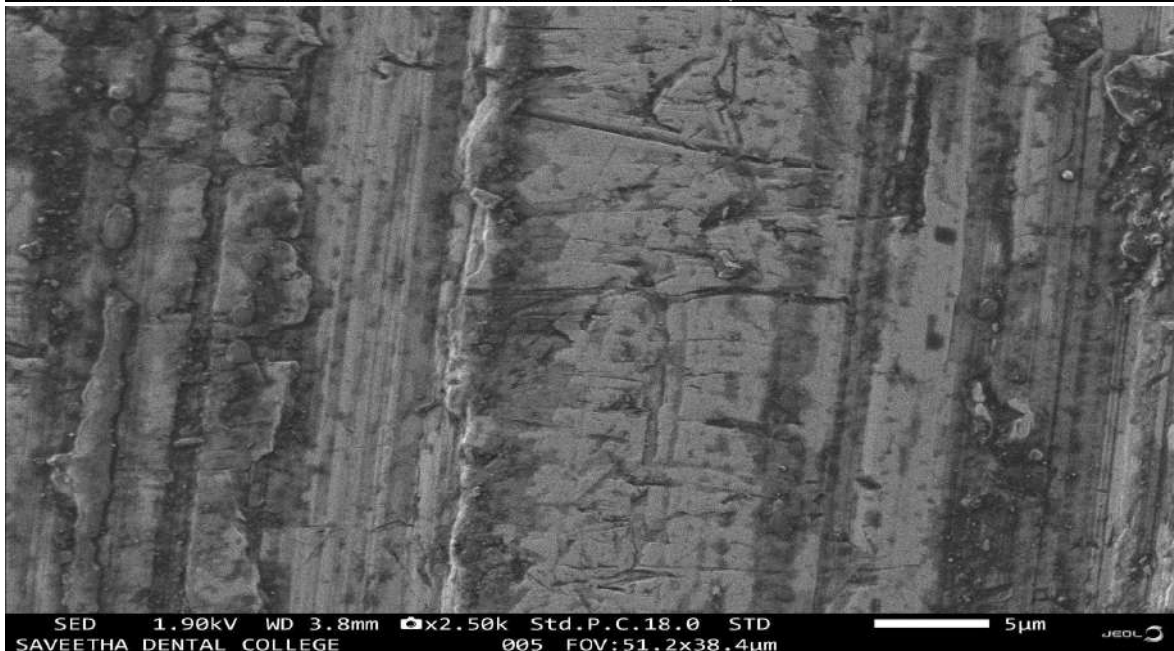
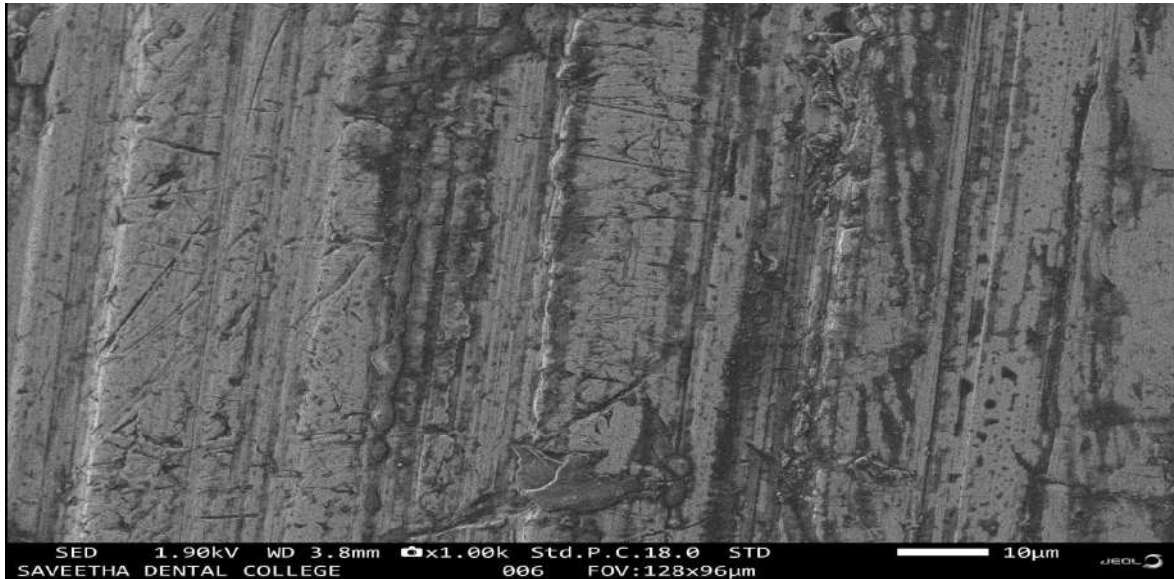




Niti SEM







The SEM images of NiTi wires revealed:

- Presence of surface irregularities and microvoids
- Pitting and cracks distributed across the surface
- Non-uniform surface texture
- Evidence of manufacturing defects

These surface features indicate increased roughness, which may contribute to higher frictional resistance during orthodontic treatment [5,8].

SEM Analysis of Stainless Steel Wire

The SEM images of stainless steel wires showed:

- Smoother and more uniform surface
- Minimal surface defects
- Reduced presence of pits and cracks
- Better surface continuity

These characteristics contribute to lower friction and improved sliding mechanics [7].

Comparative Analysis

| Parameter | NiTi Wire | Stainless Steel Wire |
|-----------------------|--------------|----------------------|
| Surface roughness | High | Low |
| Surface uniformity | Irregular | Uniform |
| Presence of defects | More | Minimal |
| Frictional resistance | Higher | Lower |
| Mechanical properties | Superelastic | Rigid |

Clinical Implications

- NiTi wires are ideal for initial alignment due to their flexibility and superelasticity despite higher surface roughness [3].
- Stainless steel wires are preferred in later stages for finishing due to their smooth surface and reduced friction [6].

Surface roughness directly affects:

- Friction between bracket and wire
- Efficiency of tooth movement
- Plaque accumulation and corrosion potential

Thus, both wires serve distinct roles in orthodontic treatment.

Discussion

The findings of this study are consistent with previous research indicating that NiTi wires exhibit greater surface irregularities compared to stainless steel wires [10,11]. The manufacturing process of NiTi alloys often results in microstructural defects, which contribute to increased roughness.

In contrast, stainless steel wires undergo polishing processes that enhance surface smoothness. This explains their lower frictional resistance and superior performance in sliding mechanics [7].

Despite their rougher surface, NiTi wires remain indispensable due to their biomechanical advantages. Therefore, the choice of archwire should be based on the stage of treatment and clinical requirements.

CONCLUSION

The present study concludes that stainless steel wires exhibit smoother surface characteristics compared to NiTi wires, resulting in lower frictional resistance. NiTi wires, although rougher, provide superior mechanical properties such as superelasticity and flexibility.

Both materials play essential roles in orthodontic treatment, and their selection should be based on clinical requirements. SEM analysis serves as an effective tool for evaluating surface morphology and guiding material selection in orthodontics.

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