Research Article

# Comparison of Structural Topography, Elemental Composition and Qualitative Analysis of two Indian mini-implants: A cross-sectional study

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## ABSTRACT

**Objectives:** This research was conducted to evaluate the surface topography, elemental composition and manufacturing defects of two brands of mini-implants commonly used in India. Clinical significance was derived based on the data of this research.

**Materials and methods:** This research was conducted on 15 orthodontic mini-implants each from two brands commonly used in India. Scanning electron microscope imaging of the head, transmucosal neck, body, and tip was done to assess mini-implant topography and manufacturing defects (n=15/group). Analysis of elemental composition was done using an X-ray Powder Diffractor (n=1/group).

**Results:** The results showed significant differences in both groups. Differences in structural topography of the implant body and tip were observed in both brands. Tip defects were detected in one brand. X-ray Powder Diffraction analyses revealed an alpha and alpha-beta titanium grain structure in both the groups.

**Conclusions:** All the mini-implants tested were composed of titanium alloy. Significant differences were found in the surface area of the threaded parts. We conclude that differences in surface topography and presence of manufacturing defects impact the primary stability of the implants thereby influencing the efficacy of orthodontic anchorage.

**KEYWORDS:** Orthodontics, mini-implant, topography, microstructure, titanium.

## INTRODUCTION

The use of orthodontic miniscrews dates back to 1945 when Gainsforth and Higley placed vitallium screws in the ramus of mandible of dogs for orthodontic tooth movement.[1] Unfortunately, this attempt did not succeed. Creekmore and Eklund (1983) placed a surgical vitallium bone screw for intrusion of maxillary incisors in a Class I patient with a very deep overbite. They achieved intrusion of 6mm and lingual torquing of 25 degrees.[2] Kanomi (1997) introduced mini-implants concretely designed for use in orthodontics.[3] Costa (1998) ushered a miniscrew with a bracket-like head which facilitated the insertion of a full-sized wire.[4]

In recent years, mini-implants have become an indispensable armamentarium in clinical orthodontic practice. The various factors responsible for their popularity are cost-efficacy, diminutive dimensions, ease of placement and retrieval, abbreviated trauma, biocompatibility, high patient acceptance and the capacity for instantaneous loading. Mini-implants are expedient in treating patients with mild to moderate skeletal discrepancies and accomplishing multifarious forms of tooth movement without straining the anchor teeth. Further, the treatment outcome is more predictable with mini-implant supported anchorage.

Many factors have an impact on the success of orthodontic implants. These include patient miscellany, the site of mini-implant insertion, macrostructural and microstructural properties of implants.

Orthodontic literature is replete with data suggesting that the efficacy and success of mini-implants depend upon their macro and microstructure properties. Several studies have been conducted over the years to inspect the properties of orthodontic implants as received from the manufacturer,[5,6,7,8,9,10] howbeit, no study has compared the properties of orthodontic implants purchased from different manufacturers commonly used in India. This study was therefore conducted to compare the surface topography, elemental composition and manufacturing defects of orthodontic implants from two commonly used Indian brands before insertion using Scanning Electron Microscopy (SEM) and X-ray Powder Diffraction (XRD).

## MATERIAL AND METHODS

**Study Design:**

A comparative study was conducted on 30 orthodontic mini-implants from two brands commonly used in India. Group 1 included 15 orthodontic mini-implants from SK Surgicals™, India (Fig 1) and Group 2 included 15 orthodontic mini-implants from FavAnchor™ Skeletal Anchorage System, India (Fig 2). SK Surgicals™ implants quantified 1.5 mm x 8 mm and FavAnchor™ quantified 1.6 x 8 mm in dimensions. Any implant with visible surface defects was omitted from the study. The armamentarium used was Scanning Electron Microscope (SEM): Model no. Jeol- Japan (JSM 6390A) and X-ray Powder Diffractor (XRD): Model no. Rigaku-Japan (Miniflex).

Fig 1.
SK Surgicals™ implant

Fig 2.
FavAnchor™ implant

**Inclusion criteria:**

Orthodontic mini-implants from two different manufacturers commonly used in India having a length of 8 mm and a minimum diameter of 1.5 mm.

Orthodontic mini-implants from different batches of the same manufacturer.

**Exclusion criteria:**

Any visible defects on the orthodontic mini-implant surface.

**Data collection Procedure:**

All implants were numbered from 1 through 30 to avoid any errors during imaging and quantifications. 15 implants from each manufacturer were used. One implant from each manufacturer was first checked for elemental composition by means of X-ray Powder Diffractor (XRD). All the 15 implants from each manufacturer were explored utilizing visual inspection to rule out any visible defects. Scanning Electron Microscopy (SEM) of the head, transmucosal neck, body and tip were carried out on all the 30 implants to study the surface topography (x25 magnification) and manufacturing defects (x100 magnification).

Statistical comparison of all parameters and values obtained after analysis was done using unpaired student t test with the value of significance at 5% ($p<=0.05$). Comparison of implant defects was done using Chi-square test.

## RESULTS

**Visual inspection:**

Visual inspection revealed no visible defects on the implant surface. The head, transmucosal neck and body of the implant appeared mundane.

**Quantitative Analysis:**

Evaluation of Pitch width between SK Surgicals™ and Favanchor™ samples (Table 1) showed that the mean pitch width was significantly high among FavAnchor™ implants compared to SK Surgicals™. Mean pitch width was 0.521±0.02 mm and 0.671±0 mm among SK Surgicals™ and FavAnchor™ samples respectively. Its range was 0.50-0.55 mm and 0.66-0.68 mm among SK Surgicals™ and FavAnchor™ samples respectively. There was a statistically significant difference found in pitch width between SK Surgicals™ and FavAnchor™ samples (P=0.001).

Comparative estimation of the thread helix angle between SK Surgicals™ and FavAnchor™ samples (Table 1) showed mean thread helix angle is significantly high among FavAnchor™ as compared to

SK Surgicals™. Mean thread helix angle was 13.46±0.19 degrees and 9.29±0.15 degrees among SK Surgicals™ and Favanchor™ samples respectively. Its range was 13.21-13.94 degrees and 9.02-9.49 degrees among SK Surgicals™ and FavAnchor™ samples respectively. There was a statistically significant difference in thread helix angle between SK Surgicals™ and Favanchor™ samples. (P=0.001).

The comparison of thread depth between SK Surgicals™ and FavAnchor™ samples (Table 1) showed mean thread depth to be significantly high among FavAnchor™ implants compared to SK Surgicals™. Mean thread depth was 0.24 mm and 0.25 mm among SK Surgicals™ and Favanchor™ samples respectively. Its range was 0.23-0.25 mm and 0.24-0.25 mm among SK Surgicals™ and Favanchor™ samples respectively. There was statistically significant difference found in thread depth between SK Surgicals™ and FavAnchor™ samples (P=0.001).

**Table 1. Linear and Angular parameters**

| | SK Surgicals™ n=15 | | | FavAnchor™ n=15 | | |
|---|---|---|---|---|---|---|
| | Mean | SD | Range | Mean | SD | Range |
| Pitch width (mm) | 0.52 | 0.01 | 0.5-0.54 | 0.67 | 0 | 0.66-0.67 |
| Thread helix angle (degrees) | 13.46 | 0.19 | 13.21-13.94 | 9.29 | 0.15 | 9.02-9.49 |
| Thread depth (mm) | 0.24 | 0 | 0.23-0.25 | 0.25 | 0 | 0.24-0.25 |

Defects on tip were found among six FavAnchor™ samples (Fig 3) while SK Surgicals™ samples (Table 2) were more or less tip defect-free. Defects like cracks and pores on surface were abundantly present in nine SK Surgical™ samples (Fig 4). Lesser defects were found on the surface of FavAnchor™ samples (Fig 5). The difference among brands was statistically significant. (P=0.019).

**Table 2. Manufacturing defects**

| | Defects on Tip | Defects Like Cracks and Pores on Surface |
|---|---|---|
| | n | n |
| SK Surgicals™ | 1 | 9 |
| FavAnchor™ | 6 | 4 |

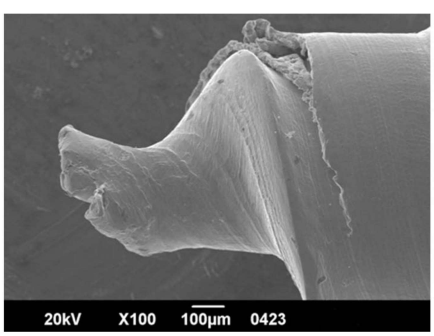


**Fig 3. Defects on tip**

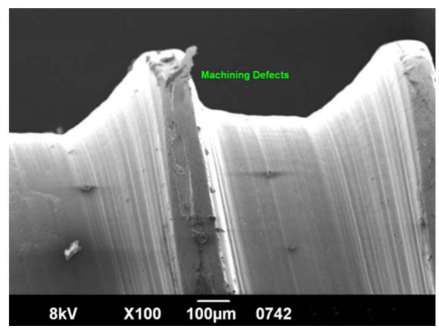


**Fig 4. Surface cracks and pores**

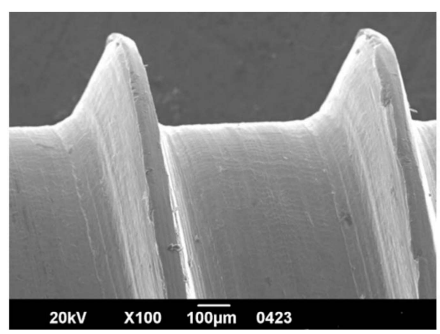


**Fig 5. Defect-free implant surface**

XRD analysis shows that the principal element in composition is titanium. Crystallographic structure reveals Alpha and alpha-beta titanium alloy (TiAl6V4). Other elements include titanium oxide (Fig 6). Surprisingly, the results showed similar structure for both groups.

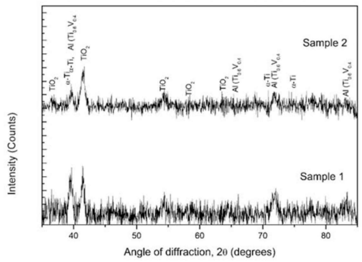


Fig 6. XRD analysis of implants

## DISCUSSION

Orthodontic literature is replete with data suggesting that the design of orthodontic mini-implants (including the shape, pitch, thread angle and thread depth) greatly affects the primary stability as well as the pull-out strength.

In the present study, the comparative evaluation of pitch width between SK Surgicals™ and Favanchor™ samples showed a statistically highly paramount difference in pitch width (P=0.001). The mean pitch width was 0.52±0.01 mm and 0.67 mm of SK Surgicals™ and FavAnchor™ samples respectively.

Walter et al (2012) found the pitch width of implants with dimensions akin to this study to be 0.6-1mm with mean pitch width of 0.71mm.[11] Katic et al (2014) found the mean pitch width of 0.69 mm and 0.73 mm for implant dimensions of 1.5x8 mm and 1.6x8 mm respectively.[12] Both of these studies found statistically significant differences in the pitch width of orthodontic mini-implants.

In a study conducted by Brinley et al (2009) it was found that lesser pitch results in more preponderant pull-out strength.[13] Contradicting results were found in a study conducted by Walter et al (2012) who concluded that greater pitch results in more preponderant pull-out strength.[11] Another study conducted by Cunha et al (2015) showed that the angle of design and the implant pitch were paramount enough to influence the primary stability of orthodontic mini-implants.[14]

In this study, the estimation of thread helix angle between SK Surgicals™ and FavAnchor™ samples showed a statistically significant difference in thread helix angle (P=0.001). The mean thread helix angle was 13.46±0.19 degrees and 9.29±0.15 degrees among SK Surgicals™ and Favanchor™ samples respectively.

Pan Ma et al (2014) conducted a study in which the results demonstrated that helix angle affects the stability of a vertically and horizontally loaded implant and, as the thread helix angle increases, the implant resistance to vertical and horizontal load abbreviates.[15]

In our study, the comparison of thread depth between SK Surgicals™ and Favanchor™ samples showed a statistically significant difference in thread depth (P=0.001). The mean thread depth was 0.24 mm and 0.25 mm among SK Surgicals™ and Favanchor™ samples respectively. Its range was 0.23-0.25 mm and 0.24-0.25 mm among SK Surgicals™ and Favanchor™ samples respectively. Walter et al (2012) found the thread depth to be between 0.18-0.27 mm. They concluded that orthodontic mini-implants with lower pitch and thread depth are arduous to fracture designating that implants with deeper threads fracture more facilely.[11]

In our research, the analysis of manufacturing defects revealed the presence of surface impurities and manufacturing defects such as cracks and surface pores. Impurities were more preponderant in SK Surgicals™ and manufacturing defects were detected in both groups. Apart from this, defects of implant tips were apparent in FavAnchor™ implants whereas SK Surgicals™ implants did not have any tip defects. Better dimensional precision was found in FavAnchor™ implants. Finishing was found to be imprecise in SK Surgicals™ and remarkably better in FavAnchor™.

XRD analysis of implants included in this research shows that the primary elemental composition is titanium alpha and alpha-beta. Other elements include titanium oxide. Findings were similar in both the groups of implants tested.

**Clinical implications**

1. FavAnchor™ implants offer better primary stability owing to increased pitch width (0.67mm), thread depth (0.25mm) and decreased thread helix angle (9.29 degrees).
2. Microscopic analysis revealed the overall structure (dimensional accuracy and manufacturing defects (except tip defects)) to be better in FavAnchor™ implants.

Scope for future studies/ limitation of the present study

1. In the present research, we included only 15 implants from each manufacturer. Future studies can be conducted comprising of greater sample size.

2. Our study only included commonly used Indian brands. Comparison of implant properties can be done with and among international brands.
3. In vivo studies can be attempted to check for the primary stability of various implants after placement into the desired site in the patient's mouth.

## CONCLUSION

1. Statistically significant differences exist between the linear and angular parameters of both groups.
2. Considerable surface defects (cracks and pores) were present in SK Surgicals™ implants.
3. Tip defects were found in FavAnchor™ implants.
4. The composition of both groups was found to be identical.
5. Better finishing was discerned in FavAnchor™ implants.
6. FavAnchor™ implants had better dimensional precision.

The Author(s) declare(s) that there is no conflict of interest

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