Original Article

Evaluation of Surface Topography of A Brand of Stainless Steel K Files; An In-Vitro Study

Surface Topography of A Brand of Stainless Steel K Files

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ABSTRACT

Objective: This study was aimed at evaluating and comparing the surface topography of a brand of stainless steel K files (Mani, Inc. Japan), acquired from local markets in Rawalpindi, Pakistan and the United Kingdom.
Study Design: Comparative study
Place and Duration of Study: This study was conducted at the Institute of Space & Technology, Karachi from November 2021 to March 2022.
Materials and Methods: 20 Mani K-Files (Mani, Inc. Japan), (ISO#25), were acquired from Rawalpindi, Pakistan and were designated as Group A, while the same were purchased from London, UK and designated as the control Group B. Both the groups were evaluated and compared in terms of surface topography using scanning electron microscope and energy dispersive X-ray spectroscopy.
Results: Qualitative analysis of the tips and flutes of the files showed substantial mechanical defects in Group A as compared to the control Group B. EDX analysis confirmed the presence of machining debris and salt deposits on the surfaces of Group A files.
Conclusion: Surface topographical features of Group A files in our study were distorted. A close monitoring of the packaging conditions and machining efficacy of the locally available stainless steel K files is required to avoid untoward clinical occurrences during the course of clinical use.

Key Words: Manual K-files, scanning electron microscopy, surface profile

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INTRODUCTION

In modern- day dentistry, the role of surface finish and wear on the efficacy of endodontic files cannot be over emphasized [1] . It is extremely important to assess the quality of files before putting them to clinical use, as files are frequently removed from the packs and utilized without being inspected for the presence of mechanical flaws and debris [2, 3] Machining defects such as milling grooves, pits and areas of metal roll over have been documented in several studies in the past.
Qualitative evaluation of the surface topography of four different rotary systems by Yamazaki-Arasaki and Ricardo Julio revealed roughness on tips and cervical regions of the as received K3 files.[4]

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Likewise, Giovani Chianello and Vivayne Leal found manufacturing defects and debris on cutting edges of all brands of K files used in their study.[5] Arantes and Da Silva confirmed the presence of micro cavities, grooves and irregular edges on tips of Twisted files used in their study.[6] In addition, Roth and Scott Whitney confirmed the presence of viable microorganisms on unused files in their study.[7] Furthermore, Linsuwanont and Parashos determined significant biological contamination in fresh files under observation.[8]
The availability of forged and poorly machined files in local markets has been serving as a nuisance to clinicians since long.[9] A varied range of instruments has been reported to fracture during the course of clinical use, including Gates-Glidden burs, carbon steel or stainless steel (SS) endodontic files (K-files, Hedstrom files, barbed broaches, and reamers). It was postulated that once a micro crack originated in an instrument; it can propagate rapidly, causing cataclysmic failure. Uneven surfaces characterized by grooves, pits, notches and metal rollover increase the incidence of such failure. These surface irregularities may act as stress raisers, initiating crack formation during clinical practice. In general, surface defects influence the ultimate strength of the material and have a major bearing on the fatigue resistance of the instrument. Moreover, manufacturing process itself leads to work hardening, creating brittle regions within the alloy. Therefore, manufacturers have strived to

improve the mechanical properties of the instruments by altering the surface or alloy microstructure.

Furthermore, complications like post op pain and flare ups, owing to apical extrusion of instrumental and intra canal debris, have been reported in several studies. Cell mediated or humoral immunological responses may arise due to foreign bodies being introduced into the periradicular connective tissue at the time of instrumentation. Presence of viable microorganisms on unused files may further aggravate these complications. Basically, all kinds of physical or chemical irritants, that may disrupt the integrity and stability of periradicular tissues, may predispose to peri apical response.

In view of an increasing incidence of instrument fractures and endodontic complications reported in clinical practices in recent years, close monitoring of machining efficacy and improvement in the quality of endodontic files is need of the hour.[10] There is a general paucity of information in our local markets regarding the manufacturing processes involved in the fabrication of endodontic files. Widespread availability of counterfeit files makes it difficult to differentiate between the forged and original ones. This calls attentions towards close assessment of machining errors in these files before putting them to clinical use. Therefore, this study was aimed at evaluating and comparing the surface topography of a brand of stainless steel K files (Mani, Inc. Japan), acquired from local markets in Rawalpindi, Pakistan. Files of the same brand, acquired from the United Kingdom, were used as the control group.

MATERIALS AND METHODS

Samples included a total of 40 stainless-steel K files (Mani, Inc. 8-3 Kiyohara Industrial Park Utsunomiya, Tochigi, Japan) of identical sizes, (ISO#25, 21mm). Of these, 20 K files, were acquired from Pakistan and were designated as Group A (Lot# R151412100), while 20 K files were purchased from London, UK and designated as Group B (Lot# R110868200).

In order to prepare samples for viewing, files belonging to each group were individually mounted on stubs with conducting carbon tape.

Files were analyzed for surface imperfections and presence of debris using scanning electron microscope (TESCAN Mira-3; Field emission scanning electron microscope) at a magnification of 500x at 20 kV. [4, 11] Following qualitative assesment, elemental composition of surface deposits was determined using energy dispersive X-ray spectroscopy.

Afterwards, files were carefully sealed in sterilization pouches. They were then subjected to a single sterilization cycle reaching 134◦c, at a pressure of 30psi for 10 minutes. (Lisa, W&H Sterilization S.r.l Italy). The sterilized files were then re-examined, using scanning electron microscope, to detect any changes in surface finish.

RESULTS

Qualitative analysis of the two sets of files showed substantial machining defects in Group A while Group B files had minimal defects. On SEM examination, Group A files exhibited ill defined tips in 20% of the samples, as shown in Fig. 1A and 1C.

On the other hand, tips oberved in all of the specimens of Group B were well defined as can be seen in Fig. 1B and 1D. Moreover, the flutes of Group A files exhibited poorly machined cutting edges in 12% of the samples, as can be seen in Fig. 1E. While in Group B samples, the flutes had well defined cutting edges, as shown in Fig. 1F. Also, mechanical defects including grooves, notches and porosities were found in 44% of samples in Group A, as can be seen in Fig. 1G, 1H, 1I and 1J. On the other hand ,in Group B files, grooves were seen on the tip surfaces of only 2 (5%) of the samples in Fig. 1B and 1D. Surface notches and porosities were not found in any of the samples in Group B.

Apart from these machining defects, surface deposits were also observed in the as received Group A files. Fig. 2*A* denotes the contaminated area of a specimen belonging to Group A which was selected for EDX analysis. Composition derived from the enrgy peaks of the electromegnatic emission spectrum, shown in Fig. 2*B*, confirmed that the depostits were of metallic nature, with an Fe content of 69.56% by weight. Moreover, polishing fragments were found in Group A files, as shown in one of the specimens in Fig. 2*C.* EDX analysis of the contaminated area of the specimen exhibited distinctive peaks of alumium (82.8% by weight), as seen in Fig. 2*D*. The presence of salt deposists was also confirmed on the surfaces of as received Group A files. Fig 1*E* denotes the area of a specimen from which the energy spectrum shown in Fig. 2*F* was acquired. The composition obtained from the energy peaks of the marked area of the specimen confirmed the presence of Na to be 33.49% and Cl to be 17.05% by weight.

The examination of file surfaces after a single cycle of steam sterilization revealed substantial improvement in surface finish of the Group A files. The amount of debris present on the surfaces of the as received files, as shown in two of the specimens in Fig. 3*A* and 3*B* was markedly decreased after autoclaving, as can be seen in Fig. 3*C* and 3*D.*

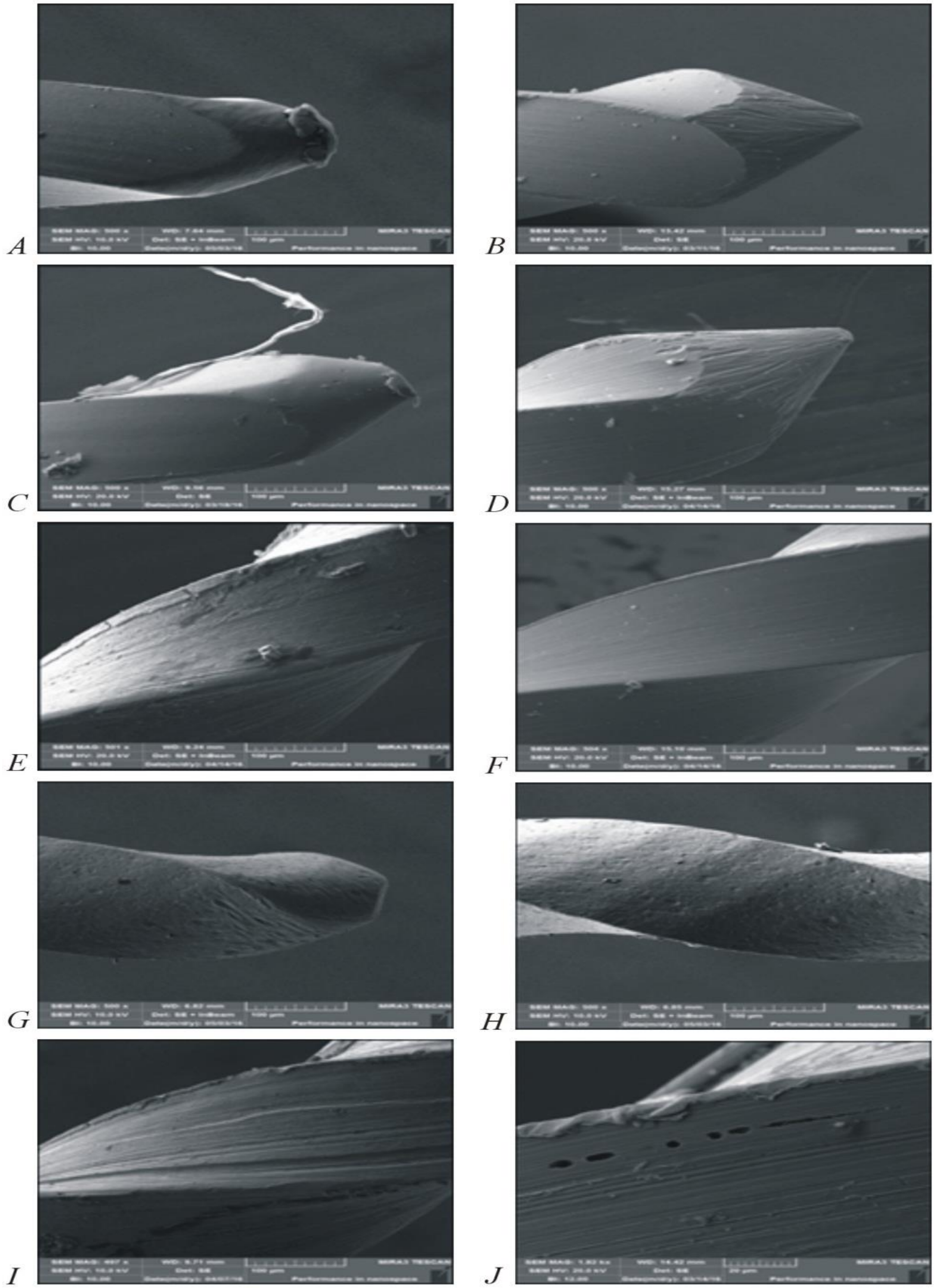

Figure No.1: Poorly defined tips in Group A files (A and C). Well defined tips in Group B files having grooves on their surfaces (B and D). Poorly machined cutting edges in Group A (E). Well defined cutting edges in Group B (F). Notches on the tips and flute surfaces in Group A (G and H). Grooves on a file surface in Group A (I). Porosities in a Group A file (J).

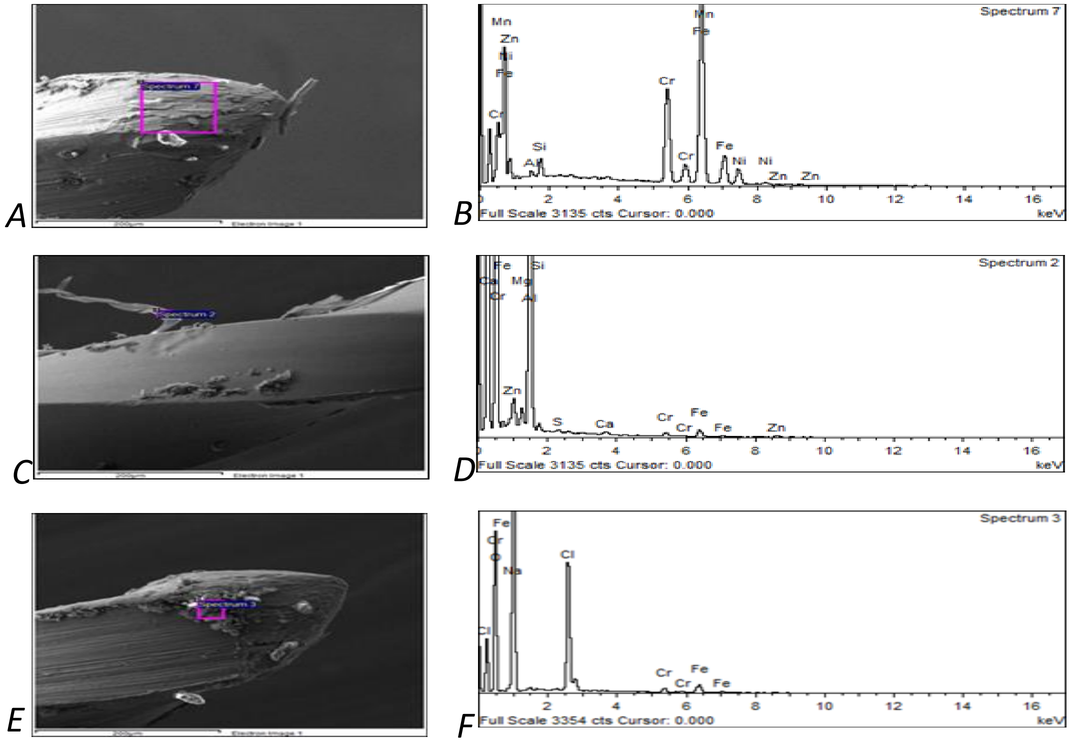

Figure No.2: Metallic deposits on a Group A file confirmed by the peaks of Fe on its elctromegnatic emssion spectrum (A and B). Polishing debris on a Group A file confirmed by the peaks of aluminium on its electromegnatic emission spectrum (C and D). Salt deposits on a Group A file confirmed by the peaks of Na and Cl on its elctromegnatic emission spectrum (E and F).

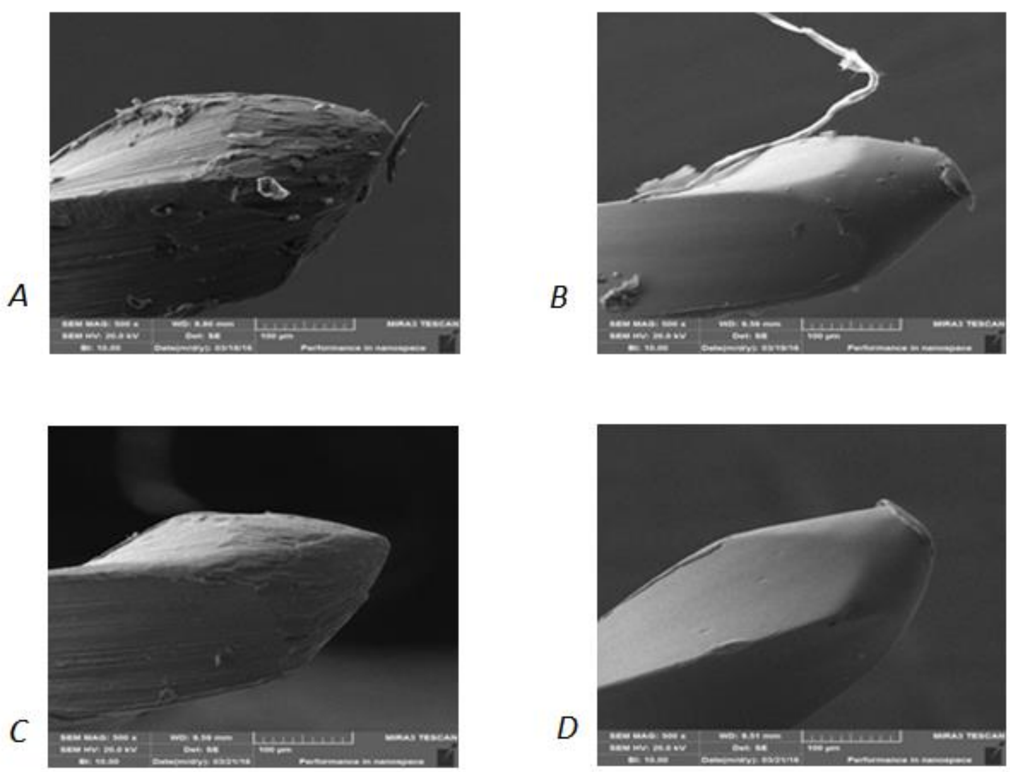

Figure No.3: Debris on the surfaces of as received Group A files (A and B). Group A files after steam sterilization showing marked decrease in surface debris (C and D).

DISCUSSION

SEM images of the tips and flutes of Group A files in our study revealed poorly machined tips and cutting edges which corroborated other researchers' evidences.[6, 12] It is a well-established fact that expensive alloying elements raise the overall prices of stainless steel alloys. However, machining elevates the expenditure of finished parts more than that of the material itself.[13] The time invested in machining each type of material is governed by the surface cutting speed in feet per minute of a processor.[14] This cutting speed variance is relatively because of the material's sulfur composition. Increased sulfur content in an alloy makes it more machinable.[14] For example, AISI 1212 carbon steel has 0.16% to 0.23% sulfur, and is deemed rather effortless to cut. On the other hand, annealed 304 stainless steels with only 0.03% sulfur have 55% lesser surface cutting speed than the carbon steel. One way to reduce the machine time and hence to save up the cost is by avoiding fine details in shapes. Fine detailing, particularly in narrow areas, requires smaller cutting tools which work slowly and hence are more expensive.[15] Poorly machined files observed in Group A in this study indicated towards compromised instrument quality on the manufacturers' part, essentially to reduce the machining cost.

The tip shape and symmetry of an endodontic file has a significant effect on its cutting efficiency.[16] Efficiency of a file is expressed in terms of the ratio of the work done to the input energy delivered to the file. An efficient file, with enhanced cutting ability requires lesser amount of time, torque, and/or pressure to achieve canal enlargement. Reduced amount of pressure, torque and time necessitates the prevention of file failure.[16] Ceyhanli and Turkun indicated that a pointed tip keeps a file pivoted within the canal enabling it to cut more uniformly with lesser abrasion, thus reducing the incidence of ledgings, zipping and transportations.[17] Hence, the likelihood of instrument failure is reduced by requiring less pressure and time for canal shaping.[17] Likewise, the importance of sharpness of flutes in file design, as seen in our control group, cannot be over emphasized. The maximum cutting force of sharp edged instruments minimizes the risk of breakage by significantly reducing the amount of stress required during canal shaping.[18]

Furthermore, surfaces of Group A files in our study exhibited mechanical defects like grooves, notches, and porosities, as well as debris, similar to a study performed by Arantes and Da Silva.[6] Mechanical defects on the instrument surface could act as local stress raisers and expedite the stress concentration process, ultimately leading to instrument failure due to coalescence of micro cavities.[19] Local entrenchment of dentinal debris in the machining grooves may also cause single overload clinical breakage of the files due to cumulative localized stresses.[19] The grooves and micro voids formed as a result of machining errors may also serve as potential sites for condensation of dentinal debris. On the contrary, smooth surfaces are less liable to the origination and growth of cracks.[20]

Moreover, metallic spikes and debris on the surfaces of unused endodontic instruments may be channeled to the root canal during chemo mechanical preparation, with a subsequent loss in working length.[21] During instrumentation, debris may also be extruded through the apical foramen, resulting in peri apical inflammation.[22]

In our study, marked decrease in surface deposits on Group A files, after being subjected to a single cycle of steam sterilization, highlights the importance of cleaning the files prior to use in dental practice. Since, file sterility cannot be guaranteed; a quick disinfection practice may be of remarkable benefit, as evidenced by Roth and Whitney. Common availability of counterfeit files in particular, makes it imperative to carefully monitor manufacturing defects and packaging conditions of the instruments before putting them to clinical use. However, the current study involved only one type of several files systems available on the market and therefore, the results obtained cannot be generalized. Hence, to draw a more decisive inference on this matter, further research is required with several brands of files in multiple sizes.

Within the limitations of this study, physical impacts of manufacturing defects, such as their effect on the flexural and torsional limits of the instruments could not be explored. Furthermore, investigations which may supplement valuable evidence to the significance of surface treatment and polishing techniques, in an effort to reduce manifestation of imperfections identified in this study are required.

CONCLUSION

The surface topographical features of Group A files in our study were distorted. While files of the same brand in control group showed very little or no distortions in comparison. Within the limitations of this study, it can be concluded that substandard counterfeit files are frequently being vended in our local markets. This may serve as a great nuisance to clinicians, as these files are hard to distinguish, unless tested and analysed.

Therefore, it is crucial to identify and curb the trade of such forged files. A close monitoring of the machining efficacy and packaging conditions of these files is required to avoid untoward clinical occurrences during the course of clinical use.

Author's Contribution:

Concept & Design of Study:	Maryam Saeedullah
Drafting:	Syed Wilayat Husain
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Revisiting Critically:	Maryam Saeedullah,

	Syed Wilayat Husain
Final Approval of version:	Maryam Saeedullah

Conflict of Interest: The study has no conflict of interest to declare by any author.

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