

An Invitro Scanning Electron Microscope (SEM) Evaluation of preparations by an Air Turbine and Electric Handpieces

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Research Article

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Abstract

Tooth preparation have for long, been the cornerstones of a well- established dental practice and are considered necessary requirements to be a successful dental practitioner. Being in the realms of general dentistry and taught at an undergraduate level in dental schools world over, these procedures have evolved with time from the use of hand instruments to motor driven instruments. Every advancement is a quantum leap from the previous technique in terms of ease of preparation, time consumed and the quality of the resultant preparation.

The electric motor driven handpiece is a recent advancement with a 1:5 advancement gear ratio which promises to deliver better results in a more comfortable manner in lesser time than its predecessor, the air turbine. Hence, this study aims to be a curtain raiser by comparing preparations using an air turbine vis-à-vis the electric motor using diamond abrasives by equating the surface smoothness using a profilometer and checking the prepared surface of the tooth under electron microscope for qualitative and quantitative analysis.

Introduction

Dentistry is gravitating towards conservative approach which includes laser, bonded restorations and biomimetic materials for better patient compliance. Tooth/cavity preparation, is an integral part of the restorative process for an optimal restoration are performed using compressed air (air turbine) or electrical energy (electric handpieces).

Handpieces, first known to be used during the Mayan era, have evolved over nearly a millennium and a half, each outdoing the earlier handpiece. However, the advent of the Electric handpiece in 1875 and the introduction of the Air turbine in 1956 revolutionised the way dentistry was performed. Being the two most sought after types of handpieces, it is encouraging to know which handpiece serves the profession and patients to a near utopian standard. ^(1,2).

The aim of the study is to compare both the handpieces in terms of resultant smoothness of preparation, development of cracks or fracture lines in the preparation while monitoring the time consumed per preparation, thereby assessing the cutting efficiency.

Materials And Methods

1. Electric handpiece (5:1 advancement gear handpiece) - Coxo- at 200,000 rpm at
2. Air turbine handpiece (1:1 handpiece) - NSK delivering a maximum rpm of 200,000 rpm
3. 80 straight fissure diamond abrasives-
4. 80 extracted Mandibular molars
5. Pink self-cure acrylic
6. Scanning Electron Microscope- Make: JOEL, Model: JCM 6000 PLUS, Volt: 5kV to 10kV

7. 3D Optical Profilometer- Vertical Resolution: 5nM, Lateral Resolution: 0.4 to 0.6 micrometre, X-Y Scan area: 1.6 sq. mm.
8. Timer on iPhone

Freshly extracted mandibular molars were collected. Sample size was kept as 80 and divided into two groups for preparation, viz.,-

- a. Group 1- Electric motor with diamond abrasive
- b. Group 2- Air turbine with diamond abrasive

Preparations were done on the buccal surfaces on all the teeth measuring about 0.5mm depth. New abrasives were used for each preparation. After the completion of all the preparations, the teeth were sectioned using diamond disks to obtain 1 mm thickness of preparations which were later mounted on an acrylic block of 2mm thickness. All the samples were observed under Scanning Electron Microscope to detect the presence of cracks/craze or fracture lines. Profilometer was used to analyse the smoothness of the preparations.

All the preparations were analysed at 500 microns.

Results

For statistical analysis, Mean Roughness (Ra) values were obtained from electron microscope data which were subjected to Independent Student T Test

Table 1- Comparison of Mean Surface Roughness [Ra] between 2 groups using Independent Student t test

Comparison of mean Surface Roughness [Ra] between 2 groups using Independent Student t Test						
Parameter	Groups	N	Mean	SD	Mean Diff	P-Value
Surface Roughness	Electric Hand piece, Abrasive	20	2.567	0.453	-0.342	0.03*
	Air Turbine, Abrasive	20	2.909	0.501		

Interpretation - Electric Hand piece, abrasive group showed significantly lesser mean surface roughness [Ra] values $[2.567 \pm 0.453]$ as compared to Air turbine, abrasive group $[2.909 \pm 0.501]$ and the difference was statistically significant at $P=0.03$.

Table 2- Comparison of smooth surface scores between 2 groups using Chi-square test

Comparison of Smooth surface scores between 2 groups using Chi Square Test						
Variable	Category	Electric Hand piece, Abrasive		Air Turbine, Abrasive		P-Value
		n	%	n	%	
Smooth Surface Scores	Score 0	0	0%	1	5%	0.01*
	Score 1	5	25%	13	65%	
	Score 2	15	75%	6	30%	

Table 3- Comparison of mean number of fracture areas between 2 groups using Mann Whitney test

Comparison of mean number of fracture areas between 2 groups using Mann Whitney Test						
Parameter	Groups	N	Mean	SD	Mean Diff	P-Value
Fracture	Electric Hand piece, Abrasive	20	0.20	0.52	-0.650	0.02*
	Air Turbine, Abrasive	20	0.85	1.09		

Table 4- Comparison of mean number of cracks between 2 groups using Mann Whitney test

Comparison of mean number of Cracks between 2 groups using Mann Whitney Test						
Parameter	Groups	N	Mean	SD	Mean Diff	P-Value
No. of Cracks	Electric Hand piece, Abrasive	20	1.00	2.13	-4.450	<0.001*
	Air Turbine, Abrasive	20	5.45	2.09		

Time taken:

1. Air turbine handpiece: Average of 3 mins for a single surface
2. Electric handpiece: Average of 1.5 mins for a single surface

Discussion

High speed handpieces are versatile instruments used to remove tooth structure effectively to produce a cleaner, smoother preparation. The era of dental handpiece began with slow speed handpiece which mostly resulted in excessive heat, vibrations and ultimately death of the pulp. Since speed influenced the chairside time, attempts were made to increase speed by mechanically generating revolutions of cutting instruments (mechanically driven handpiece) which created a lot of noise, vibrations and discomfort for the patient while the increase in pulpal temperature hadn't been addressed. To combat this problem, coolants were used in the form of water and air spray. Many other issues emerged such as reduced torque, increase in time for the preparation, increased sensitivity, stalling of the burs and increased pressure on the cutting tool to remove tooth structure.

In an attempt to overcome these problems, many new developments were made such as **air driven handpiece, gear driven handpiece, water driven handpiece, modern-day air turbine handpiece, Electric handpiece and their modifications.**⁽³⁾

In the present study, the handpieces were compared on four performance parameters in terms of the resultant preparation viz :

1. Mean surface roughness
2. Incidence of smooth surfaces
3. Mean number of fractures and Cracks
4. Time Taken per preparation

Mean Surface Roughness was found to be lesser in the samples prepared with the electric handpiece.

The samples prepared with the electric handpiece had a higher incidence of **smooth surfaces** with a few rough patches thereby delivering a more homogenous surface without the presence of obvious crests and troughs as compared to the sample group prepared using the air turbine which predominantly had a rough surface with a few smooth patches with obvious crests and troughs.

The **mean number of fractures and cracks** present in the samples were significantly lower in the samples prepared using the electric handpiece. It is safe to assume that, to obtain a statistically significant difference with this parameter has to be related to the preparation instruments majorly, although the presence of pre-existing cracks/fractures in the tooth or those induced during sectioning cannot be ruled out.

On an average, the time taken for preparation of tooth structure to remove 1mm thickness from one surface took only half of the time with the electric handpiece as compared to Air turbine. This could be attributed to constant rpm with no loss of speed and consistent torque. Therefore, it can be stated that the electric handpiece possesses a higher cutting efficiency in lesser time. While evaluating all the above parameters, the operator and the diamond points were standardised.

Air turbine handpiece was developed by John Bordon, continues to be the average clinicians' favourite owing to rapid removal of tooth structure, light touch required to operate and good ergonomic size⁽⁴⁾. It functions on the principle of compressed air which when flows through the pipe causes rotation of the rotary cutting instruments and the aerosol production which serves as a coolant ⁽⁵⁻⁸⁾. Reported drawbacks of air turbine handpiece are fluctuating torque which is directly proportional to loss of speed at minimal loads of compressed air, leading to stalling of the bur, increased bur chatter and thereby rougher preparation and increased chances of pulpal damage.

On the other hand, electric handpiece, which is an advancement gear handpiece, runs on electric power eliminating the role of compressed air in the rotation of the bur. This delivers a constant torque, thereby creating smoother preparations and bettering the cutting efficiency. The coolant is sprayed using the compressed air only when an aerosol is required to act as a coolant. Thus, the handpiece created less noise and reduced the chances of air embolism while maintaining the concentricity of burs at high loads thus eliminating bur chatter and increasing tactile sensation. Along with these features, it also produced better cutting efficiency and can also be used for endodontic purposes.^(5,9-11)

The current study attempted to create a testing environment which was effective in drawing the similarity between the two handpieces which would enable clinicians to make informed decisions in order to save chairside time and reduce patient trauma. These preparations were carried out by experienced dentists with at least 5 years of clinical experience.

Considering all these aspects, a comparison can be drawn in terms of the cutting efficiency between the two handpieces and it is safe to assume that the electric handpiece performs at par or excels the electric handpiece. This can be compounded with the opinions of many authors, who have stated the following reasons- ^(4,12-14)

1. Constant Torque and absence of stalling of bur
2. Electric handpiece worked better even at low rpm
3. Owing to the fluctuations in the volumes of compressed air which influences the functioning of the air turbine handpiece, clinicians may have to apply an additional load to increase the cutting efficiency of the drills. This phenomenon is absent in electric handpiece.⁽¹⁵⁾

While previous researches have tested these handpieces on various materials available in dentistry, we have used natural teeth in order to bring the relevance of the study as close as possible to the clinical scenarios encountered. According to Choi et al., both the air turbine and electric handpiece performed equally in terms of cutting efficiency on most of the materials such as machinable glass ceramic, high noble alloys. However, in materials that have lower surface hardness, the electric handpiece surpasses the air turbine in terms of cutting efficiency. It is our opinion that since Machinable Glass Ceramic has a surface hardness value (Knoop Hardness Number) comparable to that of Enamel (approximately 300 KHN), and high noble metal alloys and dentin are similar in terms of surface hardness (approximately 100 KHN), the electric handpiece will outperform the air turbine.^(4,15-18)

Shortcomings of the study-

- The teeth used in both groups weren't tested for inherent presence of craze lines and cracks.
- Although great precaution was exercised, craze lines might have been incorporated during the sectioning process.
- Depth of the preparation may not exactly replicate the clinical tooth preparation.

Conclusion

The choice of handpiece partly depends on the dentist's experience with the handpiece, its weight, size and shape. The reported drawbacks of the electric handpiece are that related to its large size and heavy weight. Although the popular opinion is that the air turbine handpiece is better, through this study, we are able to safely conclude that the electric motor handpiece is definitely a better choice for tooth preparation given the fact that it delivers smoother preparations because of a constant torque. This also conserves chairside time for both the dentist and the patient. The study can be further extrapolated in the future to an in-vivo format to assess the impact in an actual clinical scenario.

Declarations

Clinical Relevance:

Clinicians all over the world are employing various techniques to reduce chairside time for the patient and themselves in order to maximise productivity as well as improve patient comfort. A major chunk of dental procedures involves the use of high-speed handpieces. Air turbines are the most often relied upon handpieces. However, they come with certain inherent shortcomings which prolong the chairside time and affect the quality of the preparations as discussed above. To overcome these shortcomings, the electric handpiece is an effective alternative which mitigates most of these shortcomings and delivers high quality work in a reduced time span.

Conflict of interest-

Nil

1. Authors contribution-

Dr Pavithra Ravindra and Dr Aditya Keshav were involved in the conduction of the experiment, data collection, compiling of articles and manuscript drafting. Dr H Murali Rao contributed to the evaluation of the manuscript.

2. Ethics Approval and Consent to Participate –

Not Applicable

3. Funding-

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Figures

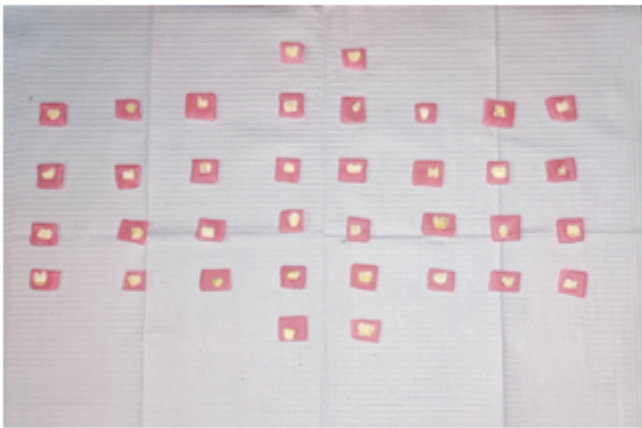


Figure 1

Samples prepared using electric handpiece with diamond abrasive; sectioned and mounted in acrylic blocks

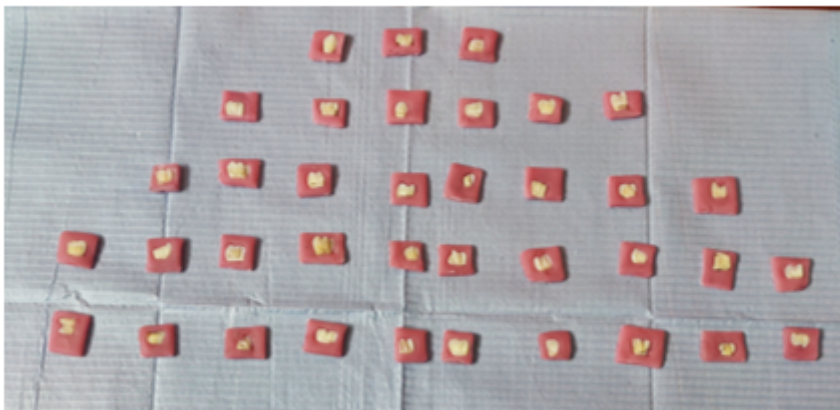


Figure 2

Samples prepared using air turbine with diamond abrasive; sectioned and mounted in acrylic blocks



Figure 3

Equipments used (Scanning Electron Microscope and Profilometer)

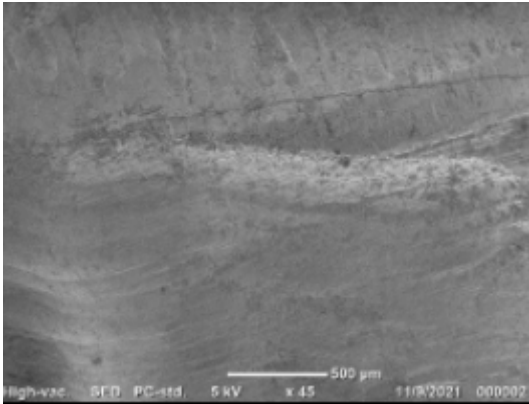


Figure 4

Group 1- Scanning Electron Microscope Section- 1mm in width, of sample prepared using Electric handpiece with diamond abrasive at 500x magnification

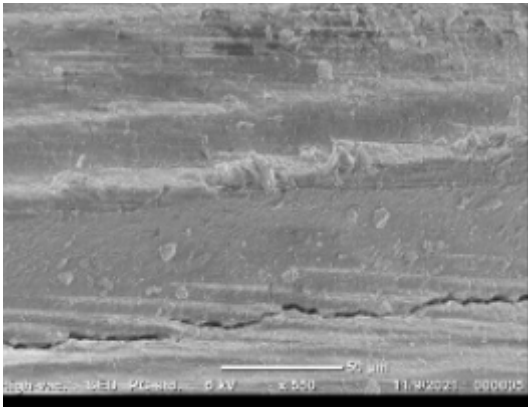


Figure 5

Group 2- Scanning Electron Microscope Section- 1mm in width, of sample prepared using Air Turbine handpiece with diamond abrasive at 500x magnification

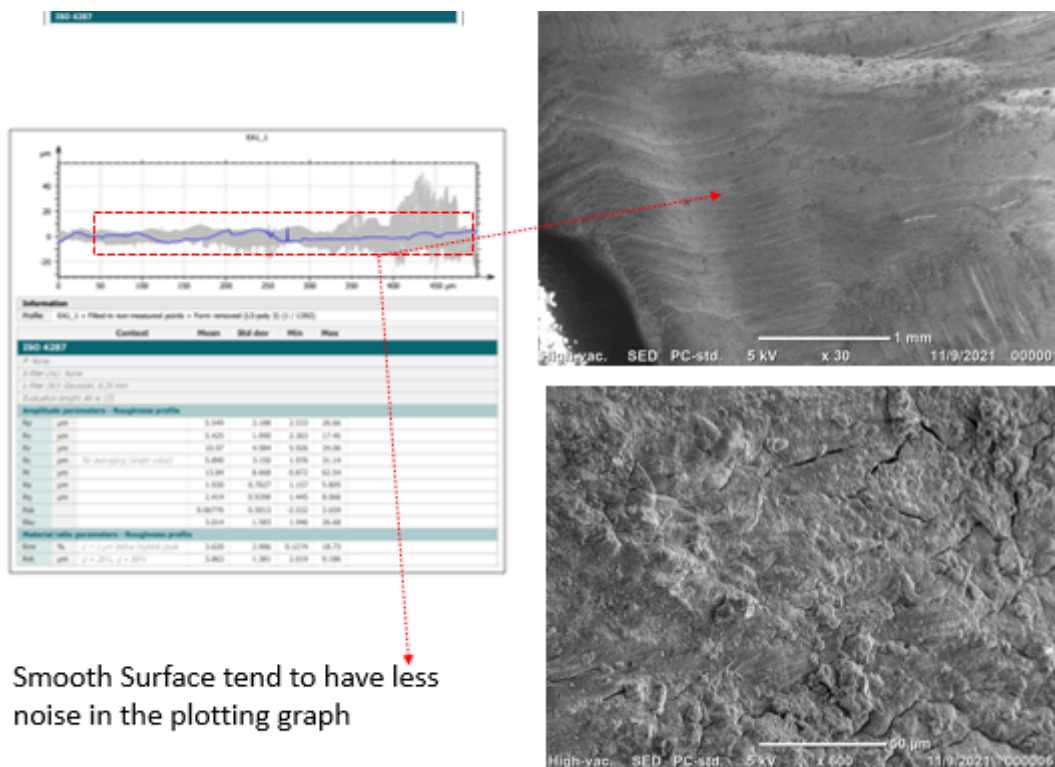


Figure 6

Group 1- Correlation of Scanning Electron Microscope result and the profilometer readings for sample prepared with Electric Handpiece to derive mean surface roughness score.

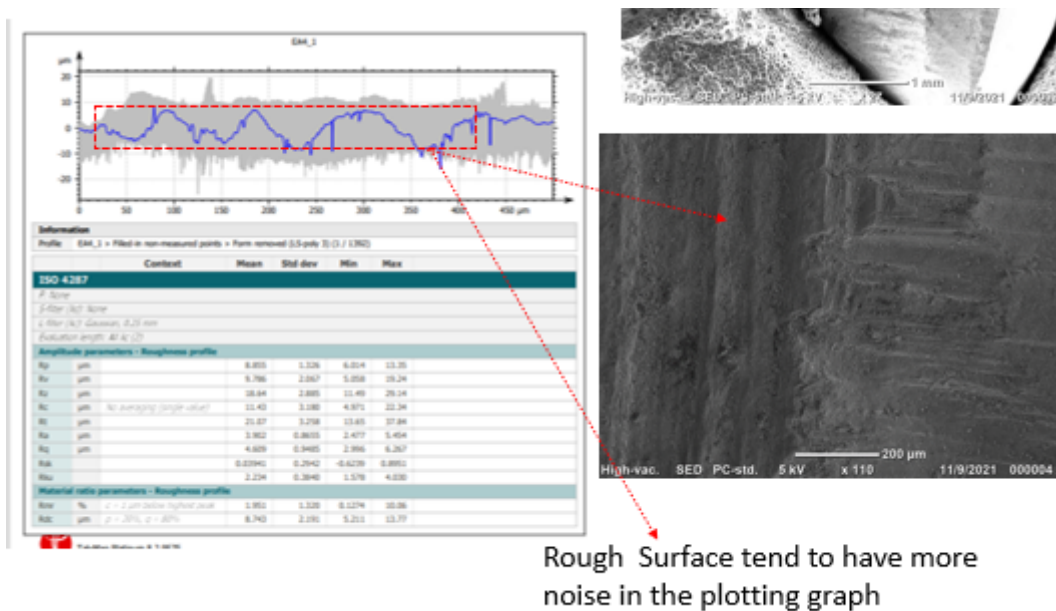


Figure 7

Group 2- Correlation of Scanning Electron Microscope result and the profilometer readings for sample prepared with Air Turbine Handpiece to derive mean surface roughness score

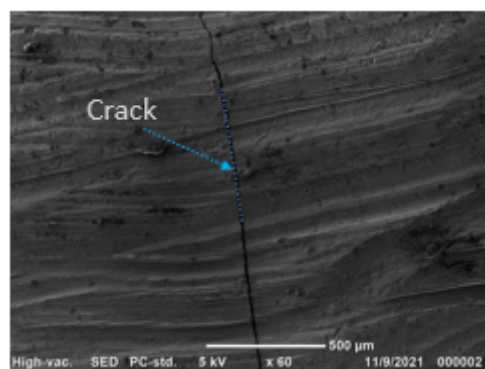


Figure 8

Scanning Electron Microscope section of a sample prepared using Air Turbine handpiece with diamond abrasive showing a distinct crack

Supplementary Files

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