ORIGINAL RESEARCH

Clinical Evaluation of Overall Efficacy and Pain Perception of Ultrasonic Oscillating Tips and Conventional High-speed Burs for Removal of Dental Caries in Children in Age-group of 6–8 Years

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Abstract

Aim: To clinically evaluate the overall efficacy and pain perception of ultrasonic oscillating tips and conventional high-speed burs to remove enamel and dentinal caries in children of ages 6–8 years.

Materials and methods: Bilateral deciduous canines with caries involving enamel or enamel and dentin were excavated by using a high-speed airrotor on one tooth and ultrasonic oscillating tips on another tooth in the same appointment. The overall response of the patient, both ultrasonic oscillating tips and airrotor along was recorded by Wong–Baker's Facial Pain Rating Scale (WBFPS) along with time taken to make each cavity and noise level generated by high-speed and ultrasonic system.

Results: Evaluation of WBFPS after every method of caries excavation showed that 84% of subjects in the ultrasonic group reported score of 0 as compared to only 24% of subjects in the airrotor group. Score 2 was reported by 16% of the subjects in the ultrasonic group and 32% of the subjects in the airrotor group. Score 4 was reported by 44% of the subjects in the airrotor group. Ultrasonic groups reported more time to remove caries as compared to the airrotor group. The ultrasonic group reported less noise as compared to the airrotor group and the difference between the two was significant.

Conclusion: Patients preferred the ultrasonic method for caries excavation because of less pain and noise. The use of ultrasonic oscillating tips is as effective in caries excavation, less painful, and more time-consuming than the conventional airrotor.

Significance: Ultrasonic oscillating tips can be successfully used in pediatric dentistry to aid patient cooperation and reduce pain during caries excavation.

Keywords: Airrotor, Comparison, Caries excavation, Ultrasonic.

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Introduction

When a child comes for his first dental visit, there are a variety of noises and sensations that can be quite alarming. Gatchel et al. have concluded that out of 105 applicants, 29.2% reported at least a moderate degree of fear associated with dentistry.[1] A pediatric dentist is responsible for alleviating the anxiety of not only the child but also the parents associated with dental treatment. According to Taani et al., the visual, auditory and tactile sensations of the drill were rated the most fear-eliciting stimuli in a study conducted among 12–15-year-old children even though high-speed airrotors are the instrument of choice for most dentists in this day and age but[2] Muppa et al. did a study in 2013 and concluded that noise in a dental setting was a factor of dental anxiety in children.[3,4] Mousumi Goswami (2017) recorded noise levels approaching 85 dBA in a pediatric dental clinic and concluded that this could have a serious effect on both providers and patients. This fact is also confirmed by National Institute on Deafness and Other Communication Disorders (NIDCD). The first ultrasonic apparatus dates from 1950.[3] Ultrasonic oscillating tips can excavate caries with less noise and low frequency of vibration without causing iatrogenic damage to adjacent teeth during proximal caries excavation.[4] Ultrasonic tips produce low sound and vibration. With such ideal properties, using oscillating tips to remove caries in pediatric patients seems very conducive. But, there haven't been many studies depicting the patents' responses to such instruments.

Therefore, a study comparing ultrasonic oscillating tips to conventional high-speed burs was undertaken to assess their effectiveness and pain perception during the removal of dental caries in children ranging from 6 to 8 years of age.

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Conflict of interest: None

Materials and Methods

Source of Data

Total of 25 patients participated, which were chosen from the outpatient department of Pediatric and Preventive Dentistry, Bharati Vidyapeeth Dental College and Hospital,Bharati Vidyapeeth (Deemed to be University), Pune, Maharashtra, India.

Inclusion Criteria

- Patients of the age 6–8 years having either deciduous or mixed dentition having two smooth surface carious lesions of deciduous canines from the same arch involving dentin but not approaching pulp.
- Patients with Frankl's behavior rating IV (definitely positive) and III (positive).

Exclusion Criteria

- Patients with Frankl's behavior rating I and II.
- Patients with only 1 decayed canine or 2 decayed canines but both on different arches.
- Patients with carious lesions involving the pulp.
- Patients are having dental pain in the deciduous canines.

An ethical committee reviewed and approved the study design and the consent forms. The parents of the patients participating in the study were made to sign a written consent.

Armamentarium

Diagnostic instruments (Fig. 1), high-speed airrotor handpiece (Allure, India), diamond point burs (round bur and straight bur) (Mani) (Figs 2 to 5), Suprasson P5 Booster, Newtron handpiece, Satelec Excavus Tip, type II glass ionomer cement (GIC) (GC Fuji II), and decibel meter (Mextech Technologies India Private Limited).

Methodology

As soon as each patient's teeth had been dried, they were examined with a dental probe and mirror. The carious lesions were differentiated by visual examination (Figs 6A and B). Behavior assessment—initially, the Corah Dental Anxiety Scale (CDA S) was used to assess each child's level of dental anxiety (Fig. 5). Selection—the carious lesion to be excavated by ultrasonic oscillating tips or by conventional high-speed burs was decided by a randomized coin toss. Cavity preparation—the cavities in both canines were prepared in a single visit. But a 10-minute rest break was given to each patient between two types of treatment. Pain perception—after each cavity was prepared, subjects immediately indicated how much pain they had felt during the procedure,

Fig. 1: Diagnostic instruments (gloves, mouth mirror, probe, explorer, and spoon excavator)

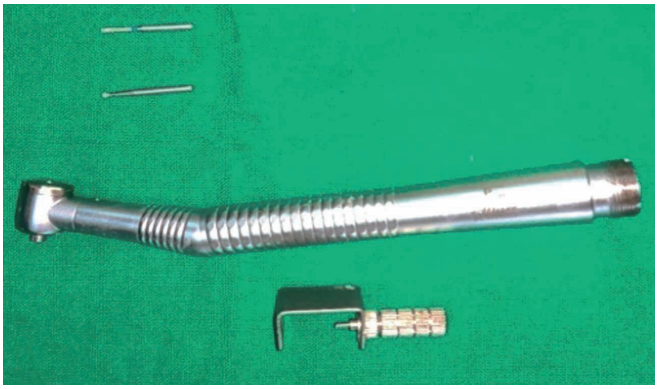


Fig. 2: High-speed airrotor and diamond tip burs

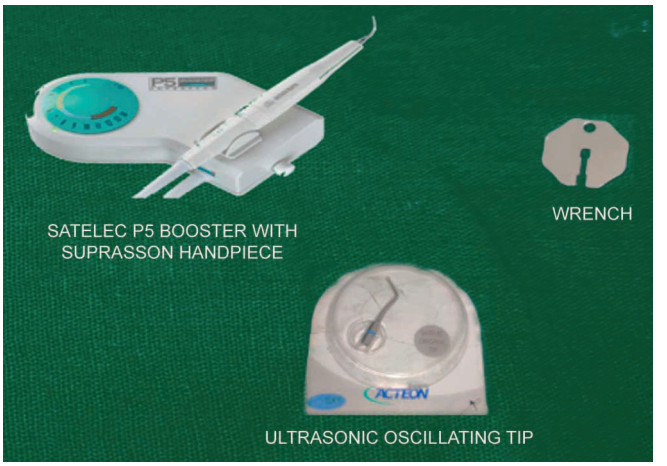


Fig. 3: Suprasson Satelec Newtron handpiece with ultrasonic oscillating tip

Fig. 4: Restoration materials (type II GIC, petroleum jelly, mixing pad, mixing spatula, cement carrier, tweezer, explorer, probe, and mouth mirror)

Corah's Dental Anxiety Scale, Revised (DAS-R)

Name _____ Date _____

1. If you had to go to the dentist tomorrow for a check-up, how would you feel about it?
   a. I would look forward to it as a reasonably enjoyable experience.
   b. I wouldn't care one way or the other.
   c. I would be a little uneasy about it.
   d. I would be afraid that it would be unpleasant and painful.
   e. I would be very frightened of what the dentist would do.

2. When you are waiting in the dentist's office for your turn in the chair, how do you feel?
   a. Relaxed.
   b. A little uneasy.
   c. Tense.
   d. Anxious.
   e. So anxious that I sometimes break out in a sweat or almost feel physically sick.

3. When you are in the dentist's chair waiting while the dentist gets the drill ready to begin working on your teeth, how do you feel?
   a. Relaxed.
   b. A little uneasy.
   c. Tense.
   d. Anxious.
   e. So anxious that I sometimes break out in a sweat or almost feel physically sick.

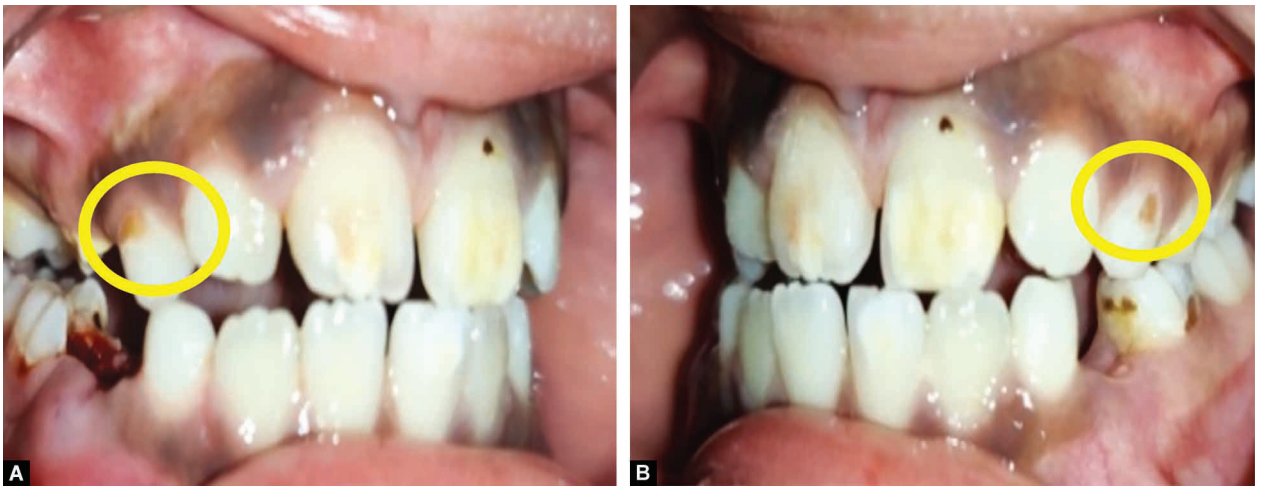
4. Imagine you are in the dentist's chair to have your teeth cleaned. While you are waiting and the dentist or hygienist is getting out the instruments which will be used to scrape your teeth around the gums, how do you feel?
   a. Relaxed.
   b. A little uneasy.
   c. Tense.
   d. Anxious.
   e. So anxious that I sometimes break out in a sweat or almost feel physically sick.

a = 1, b = 2, c = 3, d = 4, e = 5 Total possible = 20

- < 9 = mild
- 9 - 12 = moderate anxiety
- 13 - 14 = high anxiety
- 15 - 20 = severe anxiety (or phobia).

Fig. 5: CDA S

first on the right and then on the left side. A visual analog scale of 0–10 was used to assess the intensity of pain experienced during treatment by selecting one out of five schematic illustrations of facial expressions (Fig. 7). Time required—the time taken to prepare a cavity by both techniques was recorded by a stopwatch. Noise level—the amount of noise generated in each procedure was recorded by a digital decibel machine. This process is conducted in an isolated room.



Figs 6A and B: Case selection: Two primary canines in the same arch for a split study

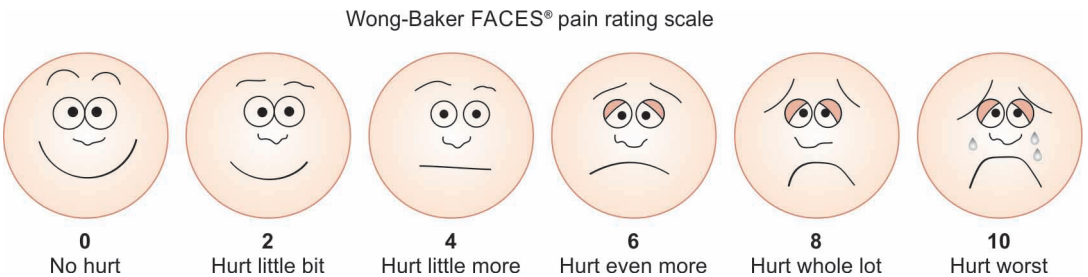


Fig. 7: Evaluation of patient's response using the WBFPS

All the cavities were restored by type II GIC (Figs 8A and B). The data obtained were compiled, tabulated and analyzed statistically.

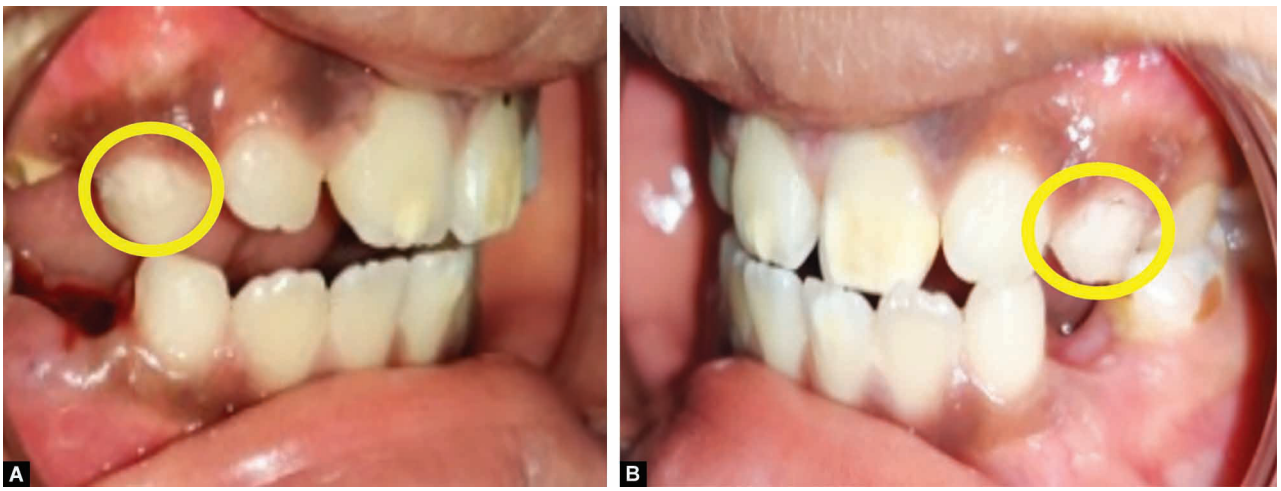
Results

A total of 44% of the patients had a score of 9 on CDA S, 40% had a score of 10, and 16% of them had a score of 12 (Table 1 and Fig. 10). Evaluation of WBFPS after every method of caries excavation showed that 84% of subjects in the ultrasonic group reported score of 0 as compared to only 24% of subjects in the airrotor group. Score 2 was reported by 16% of the subjects in the ultrasonic group and 32% of the subjects in the airrotor group. Score 4 was reported by 44% of the subjects in the airrotor group (Table 2 and Fig. 11). Comparison of mean WBFPS showed more scores among the airrotor group as compared to the ultrasonic group and significant differences existed between the two ($p = 0.001$). Ultrasonic groups reported more time to remove caries as compared to the airrotor group and the difference between the two was significant ($p = 0.001$). The ultrasonic group reported less noise as compared to the airrotor group and the difference between the two was quite substantial ($p = 0.001$) (Table 3 and Figs 12 to 14). Evaluation of patient preference showed that 88% of the subjects showed a preference for the ultrasonic group, whereas only 8% of the subjects showed a preference for the airrotor. One subject could not decide on the preference. This difference in preference was significant ($p = 0.001$) (Table 4 and Fig. 15).

Discussion

Without the advent of technology, the restorative materials available to restore the tooth needed a specific cavity design which led to cutting away the healthy tooth. However, now, dentistry has been spearheaded by minimally invasive procedures like sonic, ultrasonic treatments, remineralization techniques, Atraumatic Restorative Treatment, lasers, air abrasion etc., leaving the classic principle of G V Black—"extension for prevention" behind, as was corroborated by Mount et al. in 2000[5] This study focuses on caries excavation by two techniques—the conventional high-speed airrotor and the ultrasonic oscillation system. High-speed rotary systems have the advantage of speed and time. It rotates at a speed of 4,00,000 rpm, making it considerably faster. The heat produced is comparatively lesser than that of the micromotor. This system, coupled with a water coolant, has formed the basis of all dental treatments. In the case of interproximal lesions, the iatrogenic damage to the adjacent teeth can be seen when handpieces and burs are used.[6] Ultrasonic devices are called "microtraumatic" tools.[7] This technique does not physically excise dentin, but it wears it off using a diamond-coated tip oscillating at a frequency of about 6.5 kHz[8] ranging to a maximum frequency of 20–40 kHz.[9] According to Cianetti et al., several features make these oscillating tips an innovative technique in excavating caries:[4] (1) nominally invasive cavity preparation; (2) good visibility of caries during cavity preparation; (3) ease of removal of caries located in a hard-to-reach area; (4) Laird and Walmsley, Lussi has observed a low incidence of iatrogenic damage to adjacent teeth where proximal carious lesions are indicated;[9,10] (5) nominal noise production; and (6) minimal requirement of administration of anesthesia during patient treatment.[4] According to Yazici et al., compared with the conservative ones, ultrasonic oscillation is the only technique able to remove carious dentine without the formation of a smear layer and the consequent obstruction of dentinal tubules.[11]

Dental anxiety is a state of apprehension that something dreadful is going to occur in relation to dental treatment and it is



Figs 8A and B: The two teeth are restored by GIC

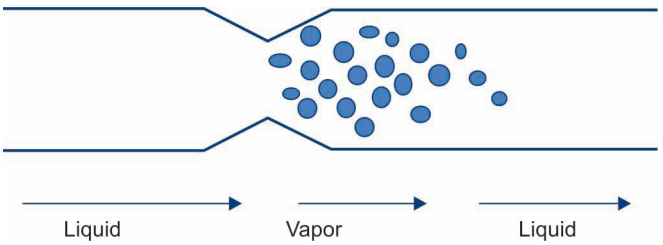


Fig. 9: Representation of cavitation effect[6]

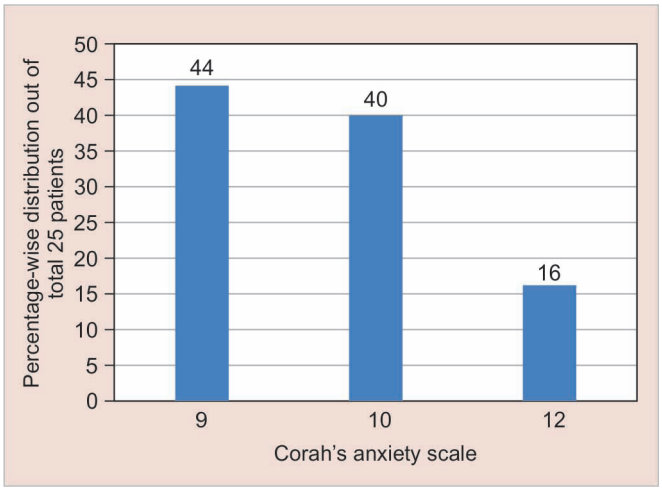


Fig. 10: CDA S of patients done before starting the treatment

Table 1: Distribution of patients with respect to CDA S

Rating	*Frequency*	*Percent*
9	11 (6F, 5M)	44.0
10	10 (6F, 4M)	40.0
12	4 (2F, 2M)	16.0
Total	25	100.0

M, males; F, females

coupled with a sense of losing control. Dental phobia represents a severe type of dental anxiety and is characterized by marked and persistent anxiety in relation either to clearly discernible situations or objects (e.g. drilling and injections) or to the dental situation in general. Dental anxiety has been said to be the fifth-most common cause of anxiety by Agras et al.[12] It is often difficult to treat such patients once they are in the dental chair. A lack of dental treatment leads to deterioration of oral health, resulting in high anxiety[13] and root canals and extractions that are more invasive. Potential anxiety-provoking stimuli have been discovered by conducting a large number of studies. In addition to the sight of the needle, the scent of different dental materials, the noise generated in a dental setting and the drill's appearance, feel, and sound, there are many other stimuli.[14] According to NIDCD, long or repeated exposures to noise levels above 85 dB can be harmful to your health. Over-exposure may also result in tinnitus (ringing in the ears). Noise-induced tinnitus may be temporary, which lasts up to 24 hours after exposure.[15]

It is important to know how an ultrasonic oscillating system actually works. In an environment where the steam pressure is higher, a liquid flown through this area is seen to boil and form vapor bubbles. Therefore, with water dissociation and formation of hydrogen (H^+) and Hydroxide (OH^-) ions, the liquid converts to gas and then back to liquid again[16] (Fig. 9). In the American Association of Endodontist Glossary, "Cavitation is defined as the formation of submicroscopic cavities or vacuums due to the vibration of a fluid because of the high-frequency alternating movement of the tip of an instrument." When these vacuums burst, there is energy in the form of heat produced and released because of circulating shock waves.[17]

Vibrations of frequencies ranging from 25,000 to 30,000 Hz are transmitted to the working end of the device by an electric generator. The shock waves created due to this remove the calculus and breakdown water molecules into H^+ and OH ions. This cavitation effect has excellent bactericidal and sterilization action.[9,17]

This was a split-mouth study, which means if there were 25 patients, there were 50 samples. Out of the 25 patients, 11 were female, and 14 were male. The specified age-group taken for this study was 6–8 years. Out of those 25 patients, two patients (8%) preferred the conventional air–rotor, 22 patients (88%) preferred their teeth to be treated by the ultrasonic technique. One patient (4%) preferred not to decide. Out of this age-group, six girls out of 11 and four boys out of 14, who were 6 years old, preferred the ultrasonic method. In the 7-year-old group, one girl and five boys preferred the ultrasonic method, while one boy did not have any preference. Amongst the 8-year-olds, two girls and four boys preferred the

Table 2: Distribution of pain score with respect to WBFPS

	WBFPS					
Groups	*Score 0 (no hurt)*	*Score 2 (hurts little bit)*	*Score 4 (hurts little more)*	*Score 6 (hurts even more)*	*Score 8 (hurts whole lot)*	*Score 10 (hurts worst)*
Ultrasonic	21 (84%)	4 (16%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Airrotor	6 (24%)	8 (32%)	11 (44%)	0 (0%)	0 (0%)	0 (0%)

Table 3: Comparison of WBFPS, time taken to remove caries and amount of noise (in dB) among both the groups

Variable	*Ultrasonic*	*Airrotor*	*Difference*	*t-value*	*p-value*
WBFPS	0.32 ± 0.75	2.40 ± 1.63	−2.08	−5.790	0.001
Time	3.71 ± 2.21	1.89 ± 1.30	1.82	3.540	0.001
Noise	87.60 ± 2.10	96.60 ± 3.43	−9.00	−11.192	0.001

Independent *t*-test; indicates significant difference at $p \leq 0.05$

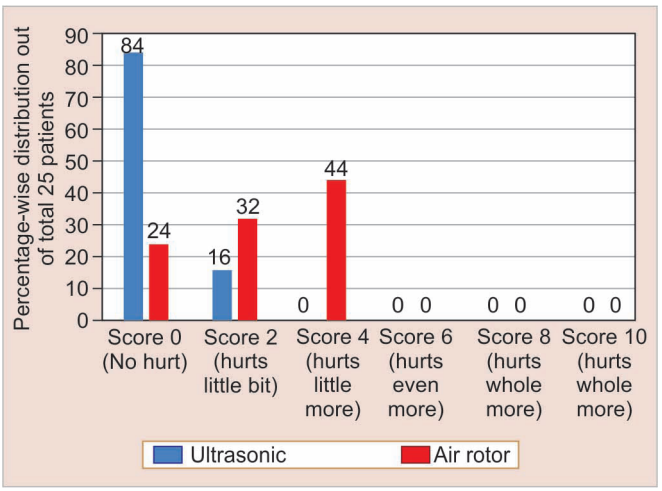


Fig. 11: Distribution of pain score according to the WBFPS (%)

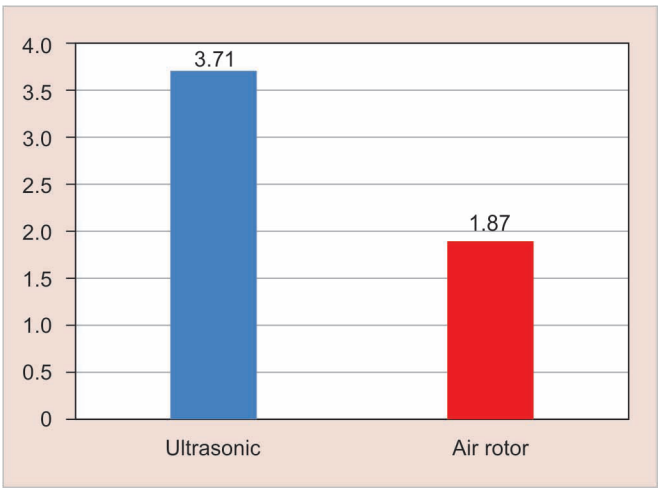


Fig. 13: Comparison of time taken to remove caries by both techniques

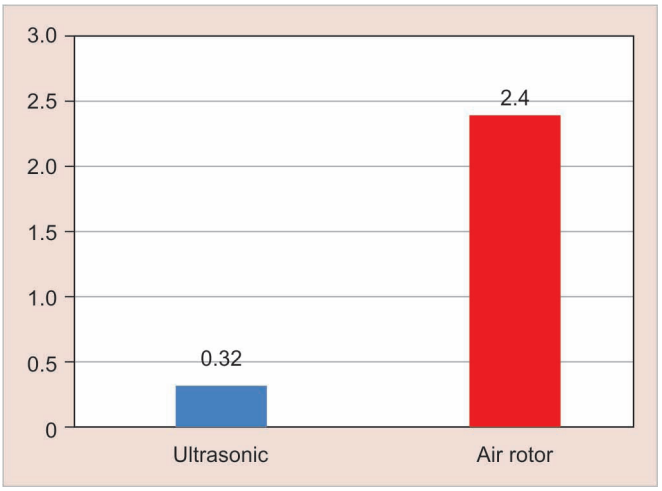


Fig. 12: Comparison of WBFPS in ultrasonic and airrotor groups

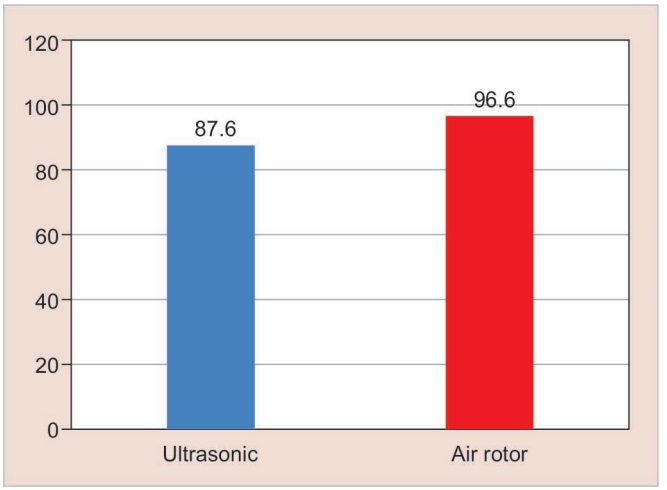


Fig. 14: Comparison of level of noise (in dB) of both ultrasonic and airrotor

ultrasonic method, and two girls preferred the conventional air–rotor method. Before starting the procedure, the patient's anxiety was evaluated by CDA S. All the patients' scores were in the range of 9–12, which denoted moderate anxiety. According to Table 1, eleven patients (44%), in those, five out of 14 boys and six out of 11 girls, had a score of 9. A total of 10 patients (40%), in those, six girls and four boys, had a score of 10. Four patients (16%), two boys and two girls, got a score of 12. According to Table 2, 21 patients (84%) gave a score of 0 on the WBFPS, while four patients (16%) gave a score of 2. During the conventional airrotor technique, six patients (24%) gave a score of 0, while eight patients (32%) gave a score of 2 and 11 patients (44%) gave a score of 4. The patients who preferred the ultrasonic technique experienced less pain in one tooth compared to the other tooth, which was treated by the conventional airrotor. The time taken

by any one technique is not uniform because of the varying depth of the carious lesion in each patient. It has been observed that the ultrasonic technique takes a long time to remove caries compared to the conventional airrotor. But this study has proven that children in the age-group of 6–8 years still prefer the ultrasonic method because of the lack of noise and fewer vibrations.

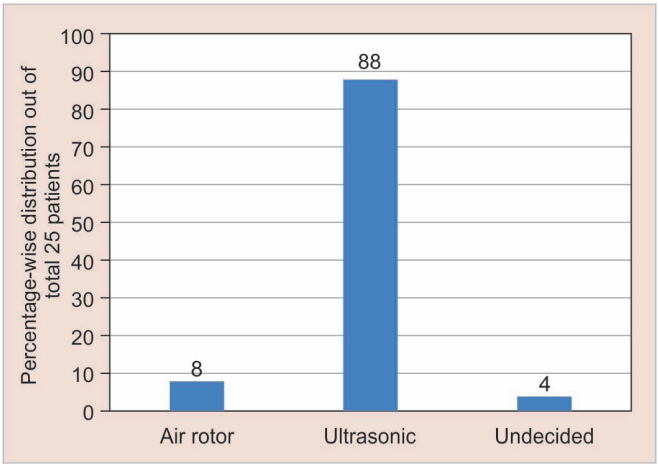


Fig. 15: Comparison of patient preference in both groups

Table 4: Evaluation of patient preference

Preference	*Frequency*	X^2 value	*p-value*
Airrotor	2 (8)	33.680	0.001
Ultrasonic	22 (88)		
Undecided	1 (4)		

Chi-squared goodness s of fit test; indicates significant at $p \leq 0.05$

One of the objectives of the study is to evaluate the noise level created by the ultrasonic system and the conventional airrotor. It was observed that with respect to the ultrasonic system, the noise level varied from 84 to 91 dBA (average 87.60 ± 2.10), while the conventional airrotor had a sound level from 89 to 101 dBA (average 96.60 ± 3.43). In their study, Kadanakuppe et al. attributed the increased noise level from the aerodynamic and structural components of each handpiece to the increased noise level from airrotor.[18] A turbulence in the air-flow pathway causes the aerodynamic component, while the bearings of the air turbine rotor cause the structural component.[19] Kadanakuppe et al. also concluded that the noise level of a used high-speed turbine is greater than that of a new one. In the present study, the noise level emitted by a high-speed airrotor was in the range of 91 to 101 dB. This fluctuation might be due to the depth of the lesion, the mineral content of the tooth and the speed at which the machine rotates. Chen et al. stated that the nonlinear interaction of ultrasound with matter (for example, when the energy is scattered at an air-water interface or in the ear itself) creates subharmonics that fall within the range of human hearing, which are then perceived as squeaking sounds (Table 5). Due to the production of subharmonics, ultrasonic frequencies can damage one's hearing.[20] Lea et al. observed that at high-power settings, along with a high-flow rate of water, the ultrasonic tip was allowed to oscillate at higher displacement amplitudes.[21–26]

The current study evaluated the overall acceptance of children of the ultrasonic method as an alternative technique for caries excavation. It is observed that the patients have preferred the ultrasonic method rather than the conventional airrotor, mostly because of the lack of noise and fewer vibrations (perceived as pain by many of them). Both techniques have their pros and cons. The ultrasonic oscillating method is preferred by the children, which

Table 5: Previous literature to support present study

Author	*Study*	*Conclusion*
Oman and Applebaum (1955)[8,22]	Studied effects of cavity cutting by ultrasonic handpiece on patients ranging from 12 to 70 years	Patients reported that virtually no pain was felt, even when dentin was cut with the ultrasonic handpiece. The annoyance caused by the vibration that results from the moving parts of a conventional rotating drill was practically absent
Postle (1958)[23,11]	Observed some of the technical advantages of ultrasonic instrumentation	Cavity preparation by this method is practically noiseless, vibration-less, heatless, and well-tolerated without local anesthesia
Antonio et al. (2005)[24]	Presented a case where excavation of the anterior teeth of a 2- year-old was done by ultrasonic method and then cured with light-cured resins	The authors recommend using the ultrasonic technique as an alternative method to excavate caries, especially in pediatric dentistry
Chomyszyn-Gajewska et al. (2006)[28]	Conducted a pilot study to compare pain perception during caries treatment in children using—the Vector system versus a mechanical method	With the Vector system, 54.8% of children and the conventional method, 29.0% felt no pain. Girls admitted to feeling more pain than boys. The Vector system is useful in treating caries in children because it minimizes the negative attitudes toward pain but takes significantly longer to use
Elmehdi (2010)[26]	Studied the noise levels originating from several dental tools as well as background noise in dental clinics in the United Arab Emirates. The effect of such noises on the anxiety and attitude of patients toward undergoing dental treatment (or coming back for a follow-up treatment) was investigated	Around 35% of adults (ages > 14 years) and 53% of youth (males and females ages 10–14 years) reported that noise from handpiece devices had an effect on their decision to undergo dental treatment and was the reason for "dropping-out" of dental follow-up treatment

increases their cooperation and reduces their dental anxiety, thus assisting the clinician in getting the treatment done faster. The ultrasonic oscillating tip does not cut healthy tissue so easily, which gives a much more conservative approach to pediatric dental treatment. The high-speed airrotor takes far less time than the ultrasonic technique, which can be useful for faster treatments in children who are already cooperative. So a clinician can start with the conventional airrotor technique and switch to the ultrasonic technique if the patient gets too uncooperative.

Conclusion

The conclusions drawn out from this study are:

- Caries excavation by ultrasonic technique is less painful than the caries excavation done by a high-speed airrotor.
- The noise level of a conventional airrotor is greater than that of ultrasonic oscillating tips.
- The time taken to excavate caries by ultrasonic technique is greater than the time taken by conventional airrotor.
- Patients preferred the ultrasonic method for caries excavation because of less pain and noise.

The use of ultrasonic oscillating tips is as effective in caries excavation, less painful, and more time-consuming but more expensive than the conventional airrotor. So the clinician can start with a conventional airrotor and then continue with ultrasonic if the need calls for it.

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