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Dental Scaling Instrument Selection by Applying Multi-Attribute Decision Making (MADM) Approach

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Abstract

Dental scaling has high importance in oral health due to its effect on preventing the teeth root destruction. Moreover, it can influence other health aspects such as reducing the risk factor of infective endocarditis. There are various devices applicable to dental scaling. It is essential to select the most appropriate type of instrument to achieve more efficient scaling. Multi-Attribute Decision Making (MADM) is a mathematical approach widely applied in for selecting the best alternative based on essential criteria. In the present research, several criteria including cost, ease of use and sterilization, durability and effectiveness considered as criteria for device selection. The experts in the related field were asked to score the criteria and corresponded alternative. According to the results, obtained by applying the TOPSIS method, Piezon Master is the most option which is mainly due to its durability and effectiveness. The second rank belongs to Cavitron due to its ease of use and sterilization in addition to affordable cost.

Keywords: Dental Scaling, MADM, Piezon, TOPSIS

1. Introduction

Dental scaling is the procedure of dental plaque removal and eliminating the dentine which impregnated with microorganisms or toxins [1,2]. The existence of dental plaque causes a change in the color of teeth and some other problems. Tooth scaling has supreme importance in dentistry since appropriate dental scaling prevents the destruction of teeth root. In addition to the benefits related to the oral aspects of dental

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scaling, it has some other advantages. According to a study carried out by Chen et al. [3] the influence of dental scaling on the risk factor of infective endocarditis investigated. The obtained results revealed that inappropriate oral hygiene is noticeably related to infective endocarditis and enhancement in oral hygiene by scaling may result in a lower risk of infective endocarditis. In another research, the impact of dental scaling on atrial fibrillation evaluated. In this study [4], 28909 cases with ages higher than 60 considered. It was observed that in the cases with dental scaling receiving, the risk of atrial fibrillation was reduced compared with others. According to these results, it can be concluded that oral hygiene enhancement by dental scaling is an appropriate and efficient approach to prevent atrial fibrillation.

Multi-Attribute Decision Making (MADM) or Multi-Criteria Decision Making (MCDM) approach is broadly employed in various fields of study [5–7]. These methods applied for preference making among various alternatives which are defined by multiple attributes which are usually conflicting [8]. The final decision is made according to the achievement of attributes. Inter- and intra-attribute comparison must be made to achieve the most appropriate decision [5]. There are several studies which employed MADM for selecting the best option for technology, method or location [9,10]. For instance, Nazari et al. [11] employed MADM to select the most appropriate site for installing solar power technology in Iran. Gupta et al. [12] applied this approach to select an appropriate material for solar cell. In addition to engineering problems, MADM is applicable for medical fields. Lee et al. [13] utilized FUZZY MCDM in order to assess the performance of the medical device producers. MADM approaches utilized in selecting the best medical treatment procedure. Hancerliogullari et al. [14] employed MCDM to assess the anesthesia methods for circumcision surgery.

Dental science have concentrated on using clinical approaches to find efficient methods and materials to achieve appropriate treatment [15,16]. In addition to these factors, the utilized devices can play a prominent role in the quality of dental procedures. Selecting the appropriate device and material is necessary to achieve a favorable treatment [16,17]. Several factors are affecting the selection of medical and dental devices. Similar to each procedure, various instruments applied for scaling by the dentists. The most conventional devices and approaches used for scaling are Air-flow, Cavitron, Minipiezon and Piezon Master which considered in the current study. The aim of the present study is using MADM, as a novel idea in the field of dentistry, to find the most appropriate device for dental scaling among the mentioned alternatives. In order to achieve this goal, the criteria involved in the selection process and their importance must defined.

2. Method

There are several MADM-based methods, 17 conventional types which are categorized based on the salient specifications and types of information, for decision making [5]. In the present study, the Technique for

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Order Preference by Similarity to Ideal Solution (TOPSIS) approach employed for selecting the most appropriate device for dental scaling. In MADM methods, there are three main steps. In the first stage, the qualitative ratings defined quantitatively. Afterward, attribute ratings are normalized to prevent computational problems related to the units difference. Finally, the selected method must be applied to obtain a solution. The criteria considered for device selection are *c1:* cost, *c2:* durability of the device, *c3:* ease of sterilization, *c4:* effectiveness and *c5:* ease of use for scaling procedure.

The main steps of this study presented in Figure 1. In a MADM problem which has (m) and (n) numbers of alternatives and criteria, the positive-ideal solution obtained as:

$$C^* = (c_1^*, \dots, c_j^*, \dots, c_n^*) \quad (1)$$

Where c_j^* refers to the highest value of the *jth* criterion in comparison with others.

Next, the negative-level solution obtained as:

$$C^- = (c_1^-, \dots, c_j^-, \dots, c_n^-) \quad (2)$$

Where c_j^- indicates the worst one of *jth* considered criterion among all criteria.

In order to calculate the normalized vector, equation 3 applied as [5]:

$$r_{ij} = \frac{c_{ij}}{\sqrt{\sum_{i=1}^{m} c_{ij}^2}} \quad i = 1, \dots, m; j = 1, \dots, n \quad (3)$$

Equation 4 is used to determine the normalized value of the vectors:

$$v_{ij} = w_j r_{ij} \quad (4)$$

In the above equation, w_j refers to the weighted of *jth* criterion.

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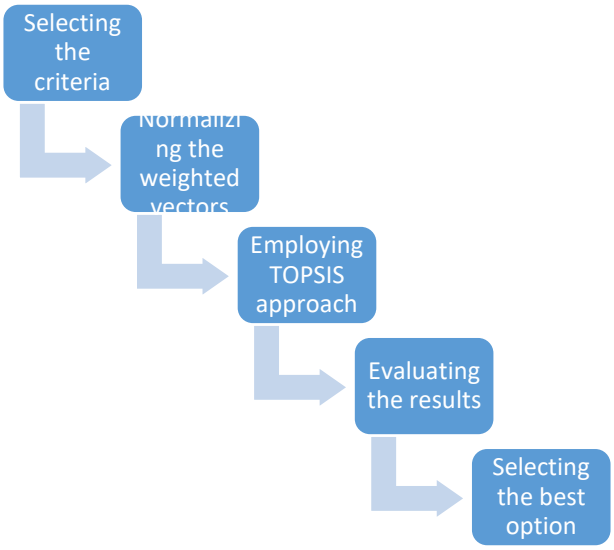

Figure 1 Process of the study

C^* and C^- refer to weighted normalized values which are defined as:

$$C^* = \{v_1^*, \dots, v_j^*, \dots, v_n^*\} = \{\max v_{ij}\} \quad (5)$$

$$C^- = \{v_1^-, \dots, v_j^-, \dots, v_n^-\} = \{\min v_{ij}\} \quad (6)$$

The difference between each criterion the positive- and negative-ideal solutions are calculated as :

$$S_i^* = \sqrt{\sum_{j=1}^{n}(v_{ij} - v_j^*)^2}, \quad i = 1, \dots, m \quad (7)$$

$$S_i^- = \sqrt{\sum_{j=1}^{n}(v_{ij} - v_j^-)^2}, \quad i = 1, \dots, m \quad (8)$$

C_i^* is defined as:

$$C_i^* = \frac{S_i^-}{S_i^- + S_i^*} \quad (9)$$

The highest value of C_i^* means the best alternative according to TOPSIS approach.

3. Results and discussion

Since the aim of the study is selecting the best alternative for dental scaling, four types of device which conventionally applied for scaling considered. Mini Piezon, Master Piezon, Air Flow and Cavitron are the alternatives considered here. Mini Piezons has better power and continuous operating range in comparison with Master Piezons. These devices used as scalers. A water tank, with pressure between 1 to 5 *bar*, and a

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voltage source required for setting it up. Generally, ultrasonic frequency ranges in these devices are between 25 to 32 KHz. There is a mother board, named Piezon board, in this device which causes vibration and produces ultrasonic waves by generating a proper voltage. Eventually, these waves have appeared as high-frequency vibrations in hand piece tips. The vibration amplitude can be reduced or increased, while the frequency is constant. There is a filter in the waterway duct. This device operating command is done by foot switch control the signal generator, flow the water and causes the stating of vibration on the tip of the device.

Piezon Masters are ultrasonic devices as well, which are in the Piezon family and have various applications such as scaling, root channel, periodontics, and endodontics. These devices generally have two working statues: in one condition, these devices work with both ultrasonic waves and solution, while in the second condition only ultrasonic waves are activated. Thus for launching the device in addition to power supply, a scrubbing solution source is used which; it could be distilled water or any proper liquid compounds. This device has different selectors which determined the Piezon power and water injection. Moreover, these devices have a pump that is controlled by the control board. There are different transes inside the device to convert input power to a suitable voltage for different inner instruments. Similar to Mini Piezons, this device has a handpiece in which the piezo rock placed in it. These devices operate by foot switch. The solution is transferred to handpiece through.

Air Flows launched by spraying aluminum hydroxide powder. Due to its low power, these devices used for removing the stain and surface masses. The operating principles of this device are similar to other ultrasonic types. These types of instrument contain a water flow instead of the scaler, without any Piezon. Two separate holes embedded for water, and the powder flows. There are three kinds of Air Flows: handy Air Flows, SI Air Flows, and SII Air Flows. The handy airflows are similar mounted on dental units and controlled by the pedals. SII airflows contain piezo rock and the handpiece. Cavitrons are based on the magnetic function system which contains a series of magnetic blades in a coil. By applying the voltage, the magnetic system induced which, results in blade vibration. These kinds of scaling devices have more irregular vibrations compared with the Piezons.

As mentioned, in MADM approaches, the qualitative data must be defined quantitatively. In order to achieve this goal, experts are requested to evaluate the criteria and the corresponding value for each alternative. 5 experienced experts in the field of medical devices and dentistry asked for filling the prepared form. In the form, scores defined between 7 and 1. 1 refers to an inappropriate condition, while the highest value, 7, means the most excellent condition.

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In the first step, experts in the field of dentistry and dental devices were requested to score for each criterion. The normalized weighted values of the criteria represented in Table 1.

Table 1 Normalized weighted values of the criteria

Criterion	Normalized value
C1	0.200
C2	0.244
C3	0.170
C4	0.230
C5	0.156

Besides, the experts were asked to score each device according to their acceptability in each criterion. The obtained normalized values for each alternative, are represented in Figure2. In the below table, A1, A2, A3, and A4 refer to Mini Piezon, Piezon Master, Air Flow and Cavitron, respectively.

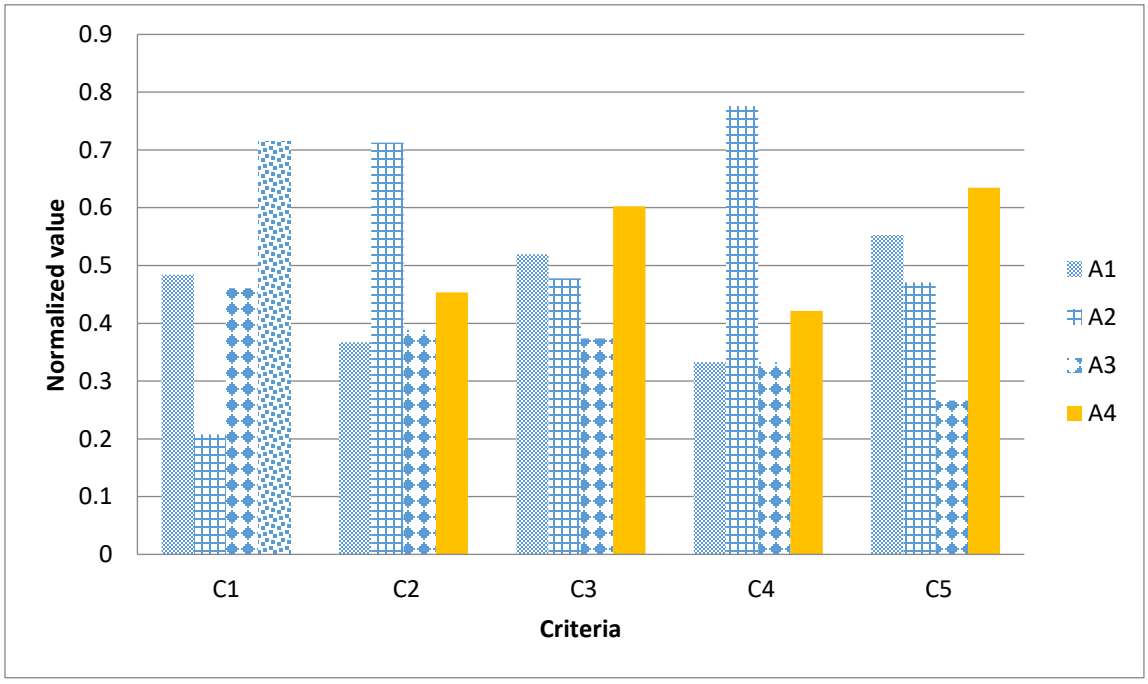

Figure 2 Normalized evaluation values

The normalized weights are multiplied by the values of the matrix to calculate the belonged value for each alternative. The results are given in Table 2. The maximum and minimum determined values for each criterion are highlighted in green and red, respectively.

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Table 2 Normalized vector for each alternative

	C1	C2	C3	C4	C5
A1	0.096796	0.089609	0.088255	0.076463	0.086193
A2	0.041484	0.173947	0.081194	0.178413	0.073424
A3	0.092187	0.09488	0.063543	0.076463	0.0415
A4	0.14289	0.110693	0.102376	0.096853	0.098962

According to the weighted criteria and scores, the best alternative for dental scaling defined. By applying equation 9, the values of C_i^* for Mini Piezon, Piezon Master, Air-Flow and Cavitron obtained as 0.34743, 0.56262, 0.24748 and 0.55030, respectively. On the basis of the calculated values, Piezon Master is selected as the best alternative for dental scaling. Although Cavitron types are the best choice based on the three criteria, the Piezon Master obtained as the most appropriate one due to their much more favorable effectiveness and durability compared with the other types.

Based on the obtained values for the alternatives by applying TOPSIS, the priorities of the devices are shown in Figure 3.

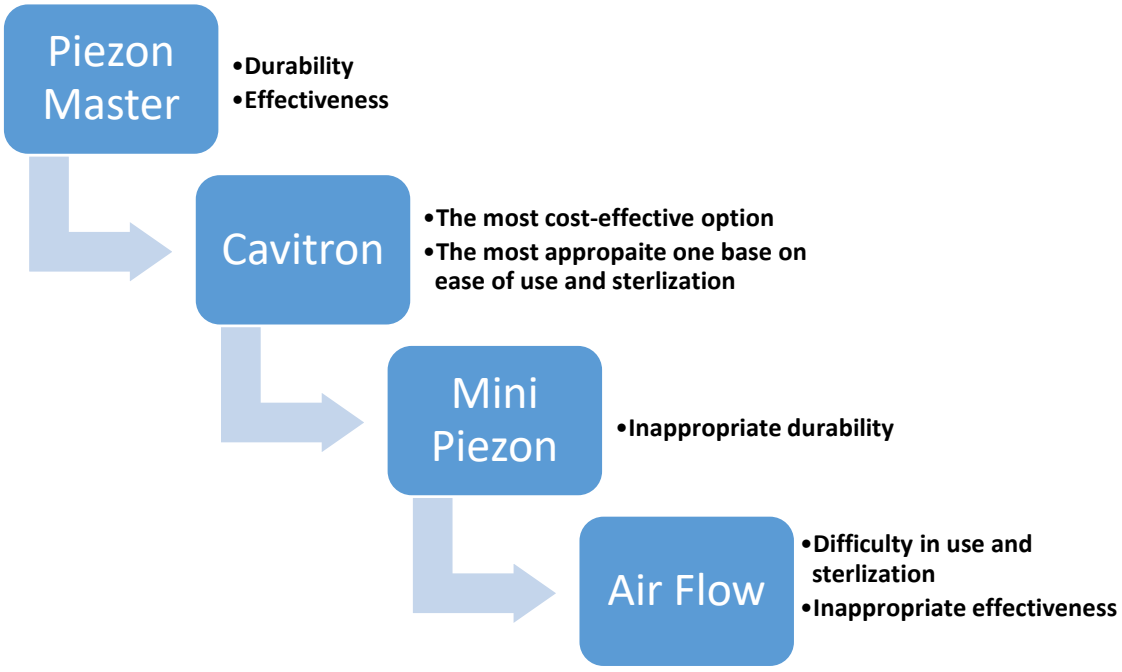

Figure 3 Dental scaling device ranking

4. Conclusion

In the present article, a MADM approach, TOPSIS, is applied to select the most appropriate device for dental scaling. Experts were asked to score the considered criteria based on their importance. Afterward, according to the scores of criteria and corresponded values for each alternative, the best option is selected. Among the devices investigated in this study, including Mini Piezon, Cavitron, Piezon Master and Air Flow, Piezon Master obtained the highest score and selected as the best option for scaling. The main advantages of Cavitron compared with other devices are its cost, ease of sterilization and ease of use. On the other hand, based on the durability and effectiveness, Piezon Master has the better condition compared with other devices. The highest score of Piezon Master in effectiveness is attributed to its various applications such as endodontic treatment in addition to its ability in scaling.

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