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Contemporary Preparation Concepts In Terms Of Effective Irrigation And 3D Obturation Of The Endodontic Space (Overview Article)

Nadya Bibova[1], Nikola Stamenov[2], Konstantin Dakov[1], Emiliya Simeonova[1]
[1]*Assistent Professor, Department of Operative Dentistry and Endodontics, Faculty of Dental Medicine, Medical University- Plovdiv, Bulgaria*
[2]*Assistent Professor, Department of Parodontology, Faculty of Dental Medicine, Medical University- Plovdiv, Bulgaria*

Abstract: ***The purpose*** *of this literature overview is to analyze individual groups of endodontic instruments for achievement of adequate root canal preparation in order to ensure efficient irrigation and hermetic obturation. Which instrument is best suited in a particular clinical situation to achieve good clinical results is a particularly topical question arising from the broad selection of endodontic tools.*
Keywords: *endodontic instruments, conicity, apical preparation.*

I. Introduction

The main goals of mechanical preparation during endodontic treatment are the following: 1) removal of infected tissues from the root canal, 2) increase of the efficiency of irrigation solutions, 3) creation of possibility to put drugs inside the canal between the visits, if needed, 4) placement of high quality permanent canal obturation.

Correlation between the thickness of the contaminating layer and the type of tools used

A smear layer is formed during the mechanical treatment of the root canals consisting of inorganic and organic elements (pulp tissue, microorganisms (MO), odontoblast growth, protein agglomerates, etc.). Its thickness and structure depend on the type of instruments used and the composition of the dentine [1]. The smear layer is the subject of many clinical studies [2]. Nowadays it is recommended to remove it completely because it blocks the dentinal tubules, prevents the penetration of the irrigating solutions in depth and reduces the adhesion of the root canal filling. This creates risks of root canal re-infection and failure of the endodontic treatment. The various endodontic instruments form different smear layers on the dentin surface of canals. Machine instruments generate faster a more even and smoother smear layer than manual instruments [3,4]. Instruments with cutting edges cut faster but create a larger contaminating layer than tools with radial surface. Reciprocal systems generate a smaller smeared layer compared to rotation systems [3]. Chelators are used to effectively remove the smear layer. The greater the amount of the created smear layer, the more chelator solution needs to be applied for its removal.

Formation of bacterial biofilm

The invasion of bacteria in the dentinal walls of the root canals is a multifactorial event. A limited number of oral bacteria have the qualities needed to participate in the invasion. The main type of MO, isolated from teeth with failed endodontic treatment or with periapical lesions, is Enterococcus faecalis [5]. Its forms create a stable biofilm and their development is modulated by the prevailing conditions of the environment [6]. Enterococcus faecalis continues to be resistant also under critical conditions where there are few nutrients as well as in the presence of antimicrobial agents such as $Ca(OH)2$, NaOCl, chlorhexidine, etc. [7]. The bacterial colonization and invasion of dentinal tubules is impacted also by other external factors, for example, inflow of nutrients and time for colonization. In the presence of an adequate microenvironment, the biofilm will have a better structured organization for a longer period. It is necessary to remove the bacterial biofilm from the dentinal walls of the root canals during the endodontic treatment. The complex root canal system is shaped with the endodontic instruments so as to fully clean the infected dentin [8, 9]. When the canal is expanded, its walls are scraped reducing the amount of infection. Excess dentin can be removed however if the preparation does not correspond to the anatomy of the root canal thus causing weakening of the root. It should be as close as possible to anatomical features such as curves and branching of the canal. The shape of the canal lumen resulting from the preparation allows for introduction of irrigating solutions and specific canal fillings using the appropriate techniques [9, 10]. During the machine tooling of the root canal it is advisable to extend it evenly, conically from apical to coronary aspect without altering the original anatomy of the canal negligently [11, 12]. The conical shape improves the effect of irrigating solutions, facilitates the introduction of the obturation materials and leads to increased density and sealing of the filling. To assist endodontic practitioners when doing the labour intensive root canal treatment, machine systems are increasingly applied thus reducing the number of instruments used. The treatment of the root canal with nickel-titanium tools improves the quality of the apical preparation and allows adequate irrigation where the solutions can have antibacterial effect on the entire length of the canal.

It has been found that not all studies give priority to rotary instruments when analyzing different aspects of preparation [13]. According to some authors hand tools have better cleaning effect than rotary tools, however machine instruments preserve better the original curve of the canal, especially in its apical part [14].

A number of researchers compared steel K files with nickel-titanium instruments with regard to the removal of bacteria from infected root canals irrigated with physiological saline solution. It is found that the bacteria were removed in only about one-third of the teeth . However, the larger diameter of the preparation of the apical part of the canal leads to a significant reduction in the number of bacteria [12]. The researchers conclude that further expansion in the apical area to No 35 does not lead to a significant reduction in the number of MO [13].

Most root canals treated with machine instruments are found to have greater sterility when large size instruments and 1% NaOCl solution as a washing agent are used [14]. It is more difficult to eliminate the bacteria from the molar canals than from the canals of premolars and canines. This is due to the fact that a large area of the walls of these teeth remains untouched by the instruments [8].

The root canals treated with machine instruments are significantly rounder in shape, have a larger diameter and are straighter than the unprepared canals. However, all instrumentation techniques leave 35% and more of the canal’s surface unchanged and therefore the endodontist relies on the subsequent irrigation to remove efficiently any residual infection [15].

Correlation between the size of the apical preparation and the efficiency of the irrigation with subsequent hermetic 3D obturation

The review of the literature shows that there is no consensus on the recommended size of the apical preparation. Theoretically, the optimal apical preparation requires a tool size equal to or greater than the largest diameter of the apical part of the canal. This would guarantee that all walls in this extremely important part of the canal will be scraped by the tool. It has been reported that tools with numbers from № 50 to № 90 are needed for the treatment of the canals of incisors, canines and premollars, and even for curved canals the size must be № 50 or № 60 [15, 16].

There are no established standard methods in clinical practice to reliably measure the size of the apical part of a root canal [17]. The size of the apical foramen is studied in different teeth. It is known that the largest foramen is found in the distal root canals of the lower molars, with an average size of about № 40 [11]. The first file that binds apically corresponds to the canal diameter in the apical region [9]. Currently the typical size of the apical preparation for curved canals of molars ranges between № 20 and № 60 in different countries around the world. It is believed that the size of the apical preparation is not critical for the treatment of pulp diseases because the dentinal tubules are not infected in depth. However, the expansion in the apical area is more important in the treatment of apical periodontitis because it supports the larger amount of preparation [15]. The larger the size of the apical preparation increases the risk of extrusion of irrigant during irrigation and canal filling [12]. It is obvious however, that size № 25 of the last tool for preparation in the apical zone leaves the walls in many canals relatively untouched. The size of the apical preparation is very important for the extrusion. The latter is a physical phenomenon of multifactorial nature. Multiple studies associate the level of extrusion with the applied technique and endodontic instruments, the amount of the washing solution, the techniques for its introduction into the canal, and with the anatomy of the apical area [18]. The larger the size of the apex, the greater the likelihood of extrusion of irrigant in the periapical tissues [19]. There may be various complications such as pain, swelling, necrosis, inflammation and even loss of the treated tooth depending on the amount and type of the extruded irrigant. The large apical preparation leads to traumatic damage to the periodontium and the consequent risk of overfilling the canal. Therefore, the modern concepts for root canal treatment require apical preparation up to № 20 – for narrow root canals, up to № 30 – for medium root canals, and up to 40 – for wide canals. Standard tools with 2% conicity require more scraping of the dentin in order to cut away mechanically the root dentin and to reduce the amount of MO. Modern reciprocal systems have greater conicity (4, 5, 6, 7, 8 %) compared to standard ones. The tools of these systems have constant conicity from D_1 to D_3 and progressively increasing conicity from D_4 to D_{16}. This ensures conservative preparation with preservation of larger amount of the root dentin which is important for the fracture resistance of the treated roots. There are three main advantages of reciprocal movement systems compared to the continuous rotation systems:

1) Greater operational safety because the areas where the instruments contact the dentin are limited to 1 or 2 points.
2) The tools advance more easily and without need for unnecessary pressure because of the different angles of clockwise and counterclockwise movement.
3) They ensure the easier and more efficient evacuation of dentin shavings during the treatment.

Correlation between conicity of endodontic instruments and level of root canal cleaning and shaping

The quality of apical cleaning and shaping depends not only on the diameter of the last tool but also on the conicity of the tool. For example, a typical tool sharpening of 2% in № 30 in manual preparation results in a canal diameter of 0.32 mm, 0.34 mm, 0.36 mm, respectively 1 mm, 2 mm, and 3 mm from the end of the working length. For tool № 30 but with 9% conicity the corresponding diameters are 0.39 mm, 0.48 mm, 0.57 mm. The greater sharpening of the tools improves the effect of antimicrobial irrigants in the apical part of the canal [20]. To provide the better cleaning of the root canal with standard tools with 2% conicity, it is necessary to prepare the canals to large sizes – above № 40. The larger the diameter of the apical preparation, the greater the risk of extrusion of irrigating solutions and overfilling of the canal. Endodontic instruments with 2% conicity do not provide adequate evacuation of dentin shavings and irrigating solutions from root canals. When using instruments with higher conicity of 4, 5, 6, 7, 8, 9 % apical preparation up to № 35 is sufficient to achieve optimal irrigation and obturation of the root canals. Extreme conicity creates a risk of fracture due to the excessive weakening of the teeth in the area of the orifices. An optimal conicity of 6-8% is considered sufficient to provide efficient irrigation along the entire length of the root canals and subsequent hermetic 3D obturation.

II. Conclusion

As shown by the literature overview, machine endodontic tools have a number of advantages over manual instruments. They clean the wall of the root canal faster and more efficiently by giving the desired conical shape necessary for efficient subsequent irrigation and hermetic 3D obturation.

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