Review Article

JRAD Journal of Research and Advancement in Dentistry

J Res Adv Dent 2018;9:1:27-31.

Tactile Controlled Activation: A Novel Technique for Cleaning and Shaping of Root Canal

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ABSTRACT

Background: The ultimate biologic objective of endodontic therapy is the prevention of periradicular disease and the promotion of healing when disease is already established. The aim of this article is to describe the application of tactile-controlled activation (TCA) technique with files for the safer and more predictable instrumentation of severely curved and challenging canals.

Keywords: Endodontic therapy, tactile controlled activation, shaping root canal.

INTRODUCTION

The prevention of periradicular disease and the promotion of healing are the primary biological objectives of endodontic therapy.The foundational principles for the successful accomplishment of the objectives are mechanical instrumentation and chemical disinfection of the root canal system.[1] This is the essential phase that will determine the effectiveness and efficiency of all subsequent procedures.[2]

Root canal shaping should satisfy specific design objectives incase of gutta-percha fillings.They are:-

- A continuously tapering funnel shape should be what the canal resembles from the orifice to the apex.
- Apically, the main canals cross-sectional diameter should be narrower at every point.
- The original dimension of the apical opening should be retained as much as possible.
- The apical foramen's original position should be preserved.[1,3]

The biological objectivesinvolved in root canal preparation are:

- Theinstruments should be confined to the limits of the root.
- Extending necrotic debris into the periradicular tissue must be avoided.
- Organic tissue must be removed from lateral extent of the root canal system in addition to the main canals.
- Enough space must be created by preserving sufficient structural dentin so as to allow irrigation and medication of the canals.[3]

In straight canals,achieving these objectives with all the instrumentation system available today is a simple and straight forward procedure when the internal anatomy of human teeth is severely curved or even bifurcated,problems of biomechanical instrumentationarise.Forsuch teeth,the instrumentation protocols and accepted basic endodontic techniques are difficult to follow.The application of tactile controlled activation(TCA) technique with controlled memory files is

Received: Sept. 21, 2018: **Accepted**: Nov. 3, 2018
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recommendedfor the safer instrumentation of severely curved and difficult canals.

TCA Instrumentation Technique

The use of hand or instrument driven files to create sufficient space for irrigation and medication of canals is known as Root Canal Instrumentation.

Various factors decide the tactile feedback of the root canal anatomy felt by the operator. They are:

- shape of the Initial Canal
- length of the Canal [with increased length ,frictional resistance increases]
- Taper of the Canal[discrepancies between the Canal and the Gauging Instrument may cause false binding sensation.]
- Curvature of the Canal [increased frictional resistance and deflection of instruments can be caused by curved canals]
- content of the Canal[different degrees of Frictional Resistance can be caused by Fibrous Or Calcified Canal Content]
- irregularitiesof the Canal[ConvexitiesOn Root Canal Walls canresultbecause of Reparative Dentin, attached Pulp Stones and Denticles.]
- types of instrument used [The Frictional Feedback can be altered by the Rigidity,Flexibility,Tapering and Restoring force of the instrument].[4]

The operator's tactile feedback during the instrumentation procedure for a given root canal and a given file differ according to the kinematic of the file used. The tactile sensation afforded by passively insertedfile (non-activated) is determined by the frictional resistance generated when the file engages the dentinal walls. The ability of the file to resist advancement around curvatures while in action helps in accurate determination of the tactile sensation with an activated (rotating or reciprocating) file. [5]

The TCA instrumentation technique is a novel approach developed keeping in mind the complexity of root canal system and the need to minimize file engagement during instrumentation. It is defined as the activation of a motionless engine driven file only after it becomes fully engaged inside a patent canal.[6]Onlyafter maximum engagement of flutesis reached and atactile feedback of anatomy is felt does this technique utilize file activation. When limited mouth opening hinders canal negotiation and complicated canal system are encountered,insertion of files passively(non activated) inside the root canal and usage of controlled memory instruments that can be pre curved before file insertion are suggested to be advantageous.

The TCA technique can be divided into in-stroke and out-stroke components.

Technical patency to length is confirmed after crossing the pulp chamber and locating canal orifices.Thehandpiece of an endodontic motor is used to mount the first file to be used and it is inserted passively inside the canal until it incurs maximum frictional resistance.The file is activated and pushed apically (In-stroke) until the activated file resists further advancement and then it is withdrawn from the canal.The file is inactivated after withdrawal and thenflutes cleaned and checked for possible deformation.Patency conformation and irrigation are done.The next time the file is inserted passively into the same canal,it reaches deeper.Activating the file after it reaches maximum depth passively will guide the file even more apically closer to length.When the file reachesworking length passively without activation and is withdrawn, then the work of that particular file is said to be completed.

Harzer apical preparation instrumentation is achieved the same way until the desired apical instrumentation width is achieved.By using file activation only where needed for advancement,TCA technique aims to minimize the time of engagement with an activated file.

By maintaining tactile sensation of the anatomy throughout the whole procedure,most of the anatomical root canal variation can be enlarged safely to the desired size,irrespective of the degree and complexity of canal curvatures. In the case of instrumentation of dilacerated canals,the controlled memory files can be precurved(in order to negotiate passively below the fulcrum of the abrupt curvature),activated at the point of maximum engagement and then withdrawn from the canal(out-stroke),instead of advancing deeper.

Engagement of the flutes will be felt more apically next timewhen the same file is inserted passively into the dilacerated canal.The file is activated the same way and withdrawn from the canal.Hence,by maintaining a tactile sensation of the anatomy throughout the whole instrumentation procedure,engine driven files can negotiate the apical third of dilacerated canal safely.[6]

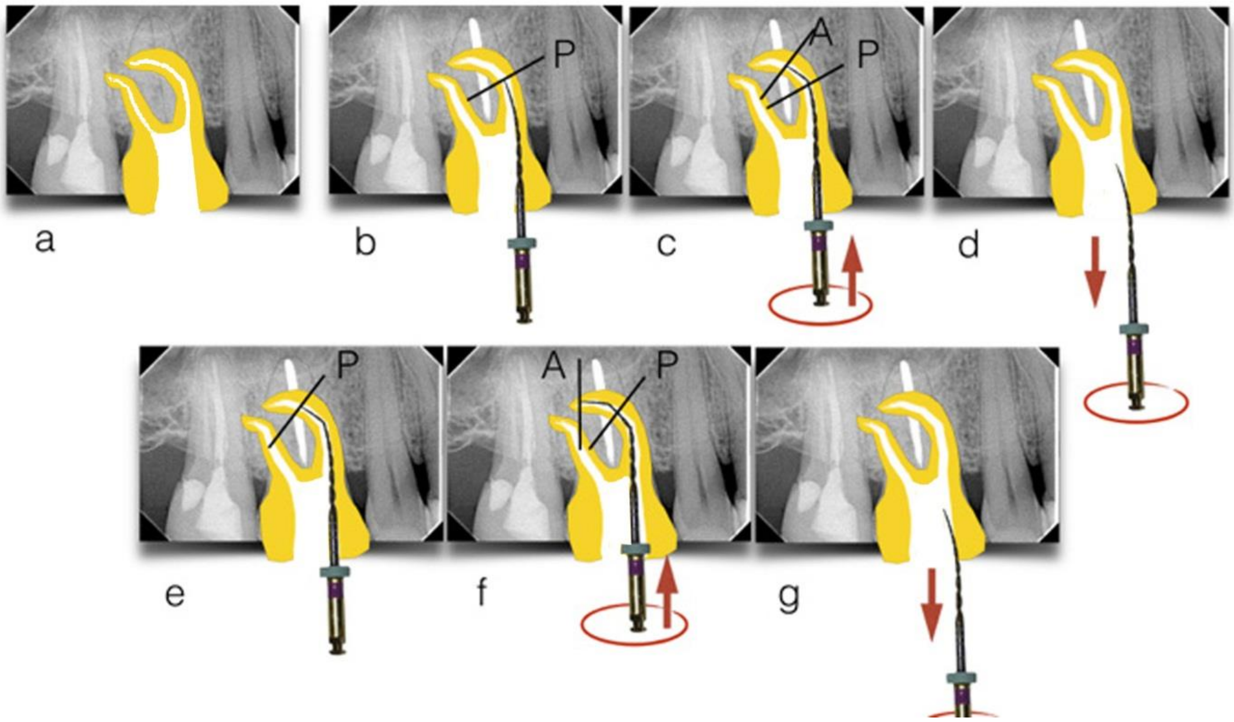


Fig 1: A) After accessing the pulp chamber and locating the canal orifices, technical patency to length is confirmed and glide path is prepared. B) The first pre-curved controlled memory file to be used is mounted on the handpiece of an endodontic motor and inserted motionless, passively inside the canal until maximum frictional resistance is felt. The point to which the file extends is referred to as *Point P or Passive Point. The first engine-driven NiTi file inserted passively into the canal should have a tip that is at least equal to or smaller than the last manual glide path file with a taper one to two times larger.* C)The file is activated and pushed apically (in-stroke) until the activated file resists further advancement. The point to which the file extends on activation is referred to as *Point A or Active Point.* d) The file is withdrawn and inactivated. The flutes are cleaned and checked for any possible deformations. Irrigation and patency confirmation follow. E) The second time that the same file will be inserted passively inside the same canal, maximum engagement is felt further apically *(Point P)*. f) Activating the file again the same way will guide the file even more apically closer to length (Point A). The file is withdrawn, cleaned, passively reinserted and activated in a sequence until the file can reaches the working length without having to activate it. Instrumentation to larger apical preparations is achieved the same way until the desired apical instrumentation width is achieved.

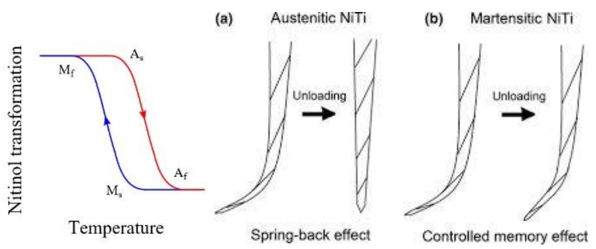
Metallurgy of CM files

Nickel-titanium alloys are softer overall than stainless steel, have a low modulus of elasticity (about one-fourth to one-fifth than that of stainless steel), have greater strength, are tougher and more resilient, and show shape memory and superelasticity (Baumann, 2004). The nickeltitanium alloys used in root canal treatment contain approximately 56% (wt) nickel and 44% (wt) titanium.[7] They can exist in two different temperature dependent crystal structures (phases) called martensite (low temperature phase, with a monoclinic B19' structure) and austenite (high temperature or parent phase, with the B2 cubic crystal structure). The lattice organization can be transformed from austenitic to martensitic and return again to austenitic phase by adjusting temperature and stress.

Preparation of the root canal causes stress to nickel-titanium files and a stress-induced martensitic transformation takes place from the austenitic phase of conventional nickel-titanium les to the martensitic phase within the speed of sound. A change in shape occurs, together with volume and density changes. This ability of resisting stress without permanent deformation — going back to the initial lattice form — is called superelasticity. Superelasticity is most pronounced at the beginning of the applied stress when a first deformation of as much as an 8% strain can be totally overcome. After 100 deformations, the tolerance is about 6%, and after 100,000 deformations, it is about 4%. Within this range, the so-called “memory effect” can be observed.[8]

Besides the stress-induced martensitic transformation, the lattice organization of nickel-titanium alloys can be altered with temperature change. When a conventional nickel-titanium austenitic microstructure is cooled, it begins to change into martensite. The temperature at which this phenomenon begins is called the martensite start temperature (Ms). The temperature at which martensite is again completely reverted is called the martensite transformation nish temperature (Mf). When martensite is heated, it begins to change into austenite. The temperature at which this phenomenon begins is called the austenite transformation start temperature (As). The temperature at which this phenomenon is completed is called the austenite finish temperature (Af), which means that at and above this temperature, the material will have completed its shape memory transformation and will display its superelastic characteristics.[9] Before 2011, the Af temperature for the majority of the available nickel titanium endodontic instruments was at or below room temperature. As a result, conventional nickel-titanium endodontic instruments were in the austenitic phase during clinical use (body temperature), showing shape memory and superelasticity. In 2011, so-called controlled memory files were introduced in endodontics. These files had been manufactured utilizing a thermomechanical processing that controls the material’s memory, making the les extremely flexible and fatigue resistant but without the shape memory and restoring force of other nickel-titanium files (Coltene/Whaledent, 2012). The Af transformation temperature of controlled-memory files is found to be clearly above body temperature. As a result, these files are mainly in the martensite phase in body temperature.[9] When the material is in its martensite form, it is soft, ductile, without shape memory, can easily be deformed, yet it will recover its shape and superelastic properties upon heating over the Af temperature. Moreover, a hybrid martensite microstructure (like the HyFlex CM™ controlled-memory files) is more likely to have more favourable fatigue resistance than an austenitic microstructure. At the same stress intensity level, the fatigue crack propagation speed of austenitic structures is much faster than that of martensite ones.[10]Aquantitative analysis based on the model of the fracture process zone showed that the martensite transformation in the shape memory nickel-titanium alloy caused a 47% increase in the apparent fracture toughness.[11]

Controlled-memory thermo-mechanical processing was combined with an innovative machining procedure for the manufacturing of rotary nickel-titanium endodontic files. The procedure is called electrical discharge machining (EDM) and results in instruments of increased surface hardness cutting efficiency and extreme fatigue resistance. The extreme flexibility and fatigue resistance of these files combined with the lack of restoring force render them ideal to be used for the instrumentation of highly curved and complicated canals.



CONCLUSION

- Controlled memory files move passively inside the highly curved or double curved canals guided only by the anatomy. This is due to the increased flexibility, increased fatigue resistance and lack of shape memory effect in controlled memory files.

- Controlled memory systems are the only ones where the files can be pre-bent for easier negotiation of challenging cases (ledges and limited mouth opening patients), even though the TCA technique can be used with all instrumentation systems, be it rotary or reciprocation.

- The TCA instrumentation technique maintains a continuous tactile feedback of the anatomy throughout the whole instrumentation procedure by minimizing the time that the files are under engagement in challenging canals.

- Approximately 75% of human root canals have a single file instrumentation protocol. This is made feasible by the wage of EDM files with controlled memory characteristics as they have increased cutting efficiency and fatigue resistance.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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