REVIEW ARTICLE

Torque and Speed in Endodontics: A Review

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ABSTRACT

Preparation of the root canal system is one of the most important procedures in endodontic treatment. There has been a constant quest for quicker, safer, and more efficient method for cleaning and shaping of root canals. The use of automated NiTi instruments was a logical development to improve the efficiency of the treatment. Separation of the instruments while preparing root canals is something that has plagued all practitioners. Therefore, an evaluation of the effect of speed and torque on the rotary NiTi instruments is of value to the clinician. The purpose of this paper is to discuss the behavioral properties of NiTi, importance of sped and torque, and the necessity for its understanding for effective, safe, and successful treatment.

Keywords: Endodontic instruments, NiTi instruments, Speed, Torque.

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INTRODUCTION

The technical demands and level of precision required for successful performance of endodontic procedures have traditionally been achieved by careful manipulation of hand instruments within the root canal space and by strict adherence to the biologic and surgical principles, essential for disinfection and healing. To improve the speed and efficiency of the treatment, recently, there has been a resurgence of mechanized or automated system for both preparation and sealing of root canal system.[1] Clinical evidence demonstrates that the root canal systems can be cleaned and shaped and obturated in three dimensions with a high degree of predictability approaching 100% success. Before 1870, dentists had no rotary driven tools. During the 1850–1870s period, various other instruments were advised to rotate burs in cavities. Early example of clockwise drill was patented in 1864, came into use by 1871, it was with the advent of the foot engine that the first dental handpieces came into use. Straight handpieces with a variety of intricate chuck-closing mechanisms became well developed during 1880, and since they were permanently linked to the foot-engine flexible cable were converted into angle handpieces by connecting so-called "lock-bit attachments" to their front ends.[2] Recent scientific and technological advancements in nickel–titanium alloys have led to the development of practical nickel–titanium endodontic files. Low torque instrumentation might also allow prolonged and safer reutilization of NiTi rotary files.[3]

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TORQUE IN ENDODONTICS

Basic Physics

Torque is a measure of how much force acting on an object cause that objects to rotate.[4] Torque also called moment of force, a tendency of force to rotate an object on axis, fulcrum, or pivot, just as a force is a push or a pull. A torque can be thought of as a twist. In simple terms, torque is a measure of the turning force on an object such as a bolt.

As shown in Figure 1, pushing or pulling the handle of a wrench connected to a nut or bolt produces a torque (turning force) that loosens or tightens the nut or bolt.

According to Marzouk Simonton and Gross (in 1997), torque is the ability of the handpiece to withstand lateral pressure on the revolving tool without decreasing its speed or reducing its cutting efficiency. Torque is dependent on the type of bearing used and the amount of energy supplied to the handpiece.[5]

Importance of Torque in Endodontics

In many aspects of practice in dentistry, especially in root canal therapy for root canal preparation, there is a turning force on an instrument. Torque is a parameter that must be controllable in root canal preparation because of different instruments, which have been used, seem to need different values of torque. In root canal preparation, safety usage of instrument depends on considering the torque at failure of instrument. In the canal instruments are subjected to different of torsional torque, if the level of torque is equal to or greater than the torque at failure (fracture), the instrument will separate. Torque values lower than the torque at fracture of the instruments can be set on the torque control handpieces. When a high torque control, handpieces are used the instrument is very active and the incidence of instrument locking.[6]

Importance of Torque - during Cleaning and Shaping

Recently, a generation of low and very low torque control motors has been introduced. Torque values as low as 1 N/cm^2 can be set on these torque control motors, these motors take into consideration and low torque at failure values of rotary instruments. If the high torque is used the instrument-specific torque limit is often exceeded, increasing the mechanical stress and the risk of fractures, thus it must be emphasized that the elastic limit of the tested instrument is found to be lower than 1 N/cm^2 when subjected to torsional testing.[7] Theoretically, an instrument used with a high torque is very active and the incidence of instrument locking and consequently deformation and separation would tend to increase, whereas a low torque would reduce the cutting efficiency of the instrument, and instrument progression in the canal would be difficult. The operator would then tend to force the instrument and may encourage instrument locking, deformation, and separation. A low torque motor should be used to limit this potential breakage, if the torque is set just below the limit of elasticity for each instrument, the mechanical stress is lower, the risk of deformation and separation is likely to be reduced.[8]

Speed in Endodontics

Handpieces and burs are among the most frequently used mechanical devices in dentistry. High-speed handpieces are used for restorative procedures and endodontic access, while low-speed handpieces are used for restorative, oral, and periodontal surgery, as well as endodontic, orthodontic, hygiene, and laboratory procedures. Speed refers not only to revolutions per minute but also to the surface feet per unit that the tool has with the work to be cut. A variety of speeds for different rotary instrumentation has been recommended by the manufacturers. Conventional endodontic motors to recent motors use a wide range of speed of 150 rpm–40,000 rpm.

Classification of Speed:[9]

According to CHARBENEAU:

a. Conventional or low speed - <10,000 rpm.
b. Increased or high speed - 10,000–1,50,000 rpm.
c. Ultra speed - >150,000 rpm.

According to STURDEVANT:

a. Low or slow speed - <12,000 rpm.
b. Medium or intermediate speed - 12,000–200,000 rpm.
c. High or ultrahigh speed - >200,000.

According to MARZOUK:

a. Ultra low speed - 300–3000 rpm.
b. Low speed - 3000–6000 rpm.
c. Medium high speed - 20,000–45,000 rpm.
d. High speed - 45,000–100,000 rpm.
e. Ultra high speed - 100,000 rpm and more.

Importance of Speed in Endodontics

In endodontics, speed varies from 150 to 40,000 rpm. Although greater the speed the more is the cutting efficiency, higher speeds have more disadvantages such as:

1. Loss of tactile sensation.
2. Breakage of instruments proceeded by flute distortion.
3. Change in anatomical curvature of canal.
4. Loss of control.

Relation between Torque and Speed in Endodontics

Cutting efficiency is actually a balance between the speed and torque delivered to the bur. Air driven high-speed handpieces provide higher speeds, but their torque is much lower, then what is offered in electric handpieces so their cutting efficiency is lower.[10]

The less efficient the handpiece the more heat is generated. As it cuts, the operator must apply greater force to cut the material. As force is increased, frictional resistance also increases and heat generated is increased. These can both add to patient discomfort during the procedure and pulpal trauma after the clinical treatment. During root canal preparation, all the instruments are subjected to different levels of torque. If the level of the torque is equal or greater than the torque at deformation or at separation, the instrument will either deform or separate.[11] Theoretically, with low torque control motors, the motor will stop rotating and can even reverse the direction of rotation when the instrument is subjected to torque levels equal to the torque values set on the motor. Thus, instrument failure could be avoided Gambarini, in 2001, and Berutti *et al*., in 2004, stated that endodontic motors with lower torque values cause lower cyclic fatigue in NiTi rotary instruments.[12]

Superelastic NiTi Rotary Instrument

Shape memory alloys, such as nickel–titanium, undergo a phase transformation in their crystal n structure when cooled from the stronger, high-temperature form (austenite) to the weaker, and low-temperature form (martensite). This inherent phase transformation is the basis for the unique properties of these alloys, in particular, shape memory effect and superelasticity.[13]

This effect is caused by the stress-induced formation of some martensite above its normal temperature. Because it has been formed above its normal temperature, the martensite reverts immediately to undeformed austenite as soon as the stress is removed. The superelastic behavior is typically represented by the martensitic yield plateau within which the stress remains approximately constant until the martensite finish transformation stress, a value which is slightly lower than the elastic limit, is reached (Figure 2).[14,15]

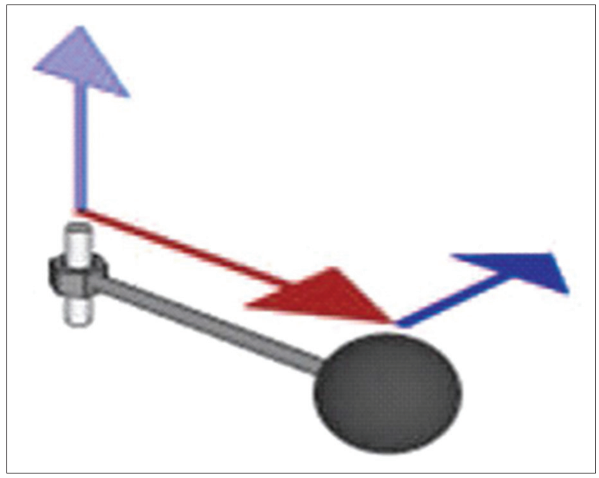

Figure 1: Turning force

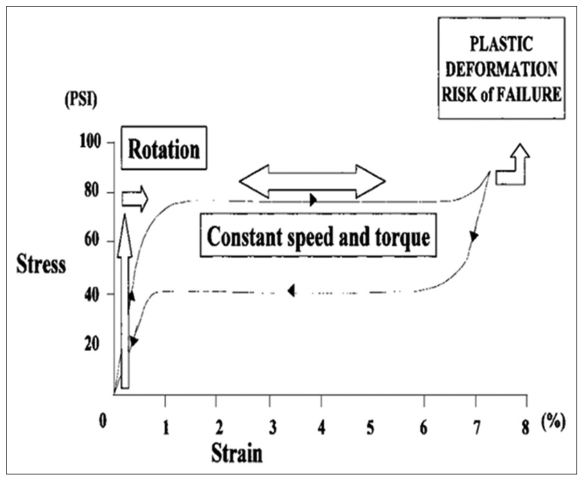

Figure 2: Super elastic behavior of NiTi alloy

Slow Speed, Low torque (Right torque) Motors

On the contrary, in curved or calcified canals, the resistance is high and the instrument may become blocked near the tip. In these situations, the high torque provided by the motor might immediately lead to fracture of the blocked instrument, especially since the clinician usually has no time to stop or retract the instrument so it is changed to slow speed low torque or preferably right torque motors since each instrument has a specific ideal (right) torque. The values are usually low for the smaller and less tapered instruments, and high for the bigger and more tapered ones. To minimize the risk of iatrogenic errors and intracanal breakage, the instruments should be operated in a range between the martensite starts, which is a safe and efficient load.[16]

Endodontic motors available in the world market according to timeline

19th century	20th century	21st century
DENTSPLY	X-Smart Plus	X-Smart IQ
AEU-20T Endodontic System	X-Smart Dual	
AEU-25T Electronic Endodontic	NSK (40)	
System (Endodontic DTC)	ENDO-MATE TC2	
Pro-Mark	ENDO-MATE DT	
E3 Torque Control Motor	ANTHOGYRE	
X-Smart	ORIKAM	
	Ionyx Endy NT2	
	KAVO	
	ASEPTICO	
	NOVAG	
	VDW	
	W and H	
	MORITA	
	SIRONA	`
	SYBRON ENDO	
	META BIOMED	
	MARATHON	

NEOLIX ENDO
MAN-E

DISCUSSION

Recent scientific and technological advancements in nickel–titanium alloys have led to the development of practical nickel–titanium endodontic files. Low torque instrumentation might also allow prolonged and safer reutilization of NiTi rotary files. Among the possible disadvantages, we should mention the fact that the use of low torque motors is likely to change tactile and mental awareness, but operative sequences as well, because cutting efficiency is reduced.[6]

Theoretically, an instrument used with high torque is very active and negotiation of root canals is easier, even if the incidence of instrument locking and consequent separation would tend to increase.[7]

Whereas with low torque, the cutting efficiency would be reduced and instrument progression in the canal would be more difficult. In such cases, if clinicians tended to force the instruments apically, they would increase the risk of locking and separation.[9]

The rule "never force a rotary instrument" is critical for both low and high torque NiTi rotary instrumentation. Clinicians who are accustomed to high torque instrumentation might complain that when the lower "safety" values are selected the autoreverse function often starts immediately after the rotary file is locking into the root canal.[10]

There are different types of endodontic motors available in the market, and the torque and speed of different endodontic motors are different as mentioned as per manufacturer, X- Smart is one of the well-known endodontic motors having speed range: 120–800 rpm, torque control range: 0.6–5.2 N.cm, and the torque value changes for different files this may be due to the difference in the manufacturer and structural difference between files.

If the high torque and speed increase, there having the procedural errors such as ledge formation, file breakage, canal blockage, cervical canal perforation, midroot perforation, and apical perforation. Theoretically, the problem of fracture of the instruments comes with an inaccurate torque and speed used for instrument.[11]

Because a specific limit torque (close to the limit of elasticity) can be set for each instrument size and type and that the motor stops if it is loaded up to this instrument-specific limit torque, it was a rare occurrence to see irreversible material damage (plastic deformation) and instrument fractures.[12,13]

Clearly, the use of the motor warrants that proper experimental studies and clinical trials are carried out to determine both effectiveness and safety of rotary instrumentation with specific limit torque settings.[17-21]

CONCLUSION

The problem of fracture of the instruments and failure of the endodontic treatment comes with an inaccurate torque and speed used for instrument.

Instrument used with a high torque is very active and the incidence of instrument separation would tend to increase.

Whereas a low torque would reduce the cutting efficiency of the instrument, and instrument progression in the canal would be difficult, the operator would then tend to force the instrument and that may lead to instrument locking, deformation, or separation.

Preclinical training and use of the rotary systems according to specific guidelines are necessary to reduce the incidence of instrument locking, deforming, and separation.

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