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Intelligent Torque Control Motors in Dentistry

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1. Introduction

Perhaps no instrument has more optimized in dentistry and the dentist over the past century in the mind of the public than the dental headpiece. Prior to 1870 dentists had no driven rotary tools. During the 1850-1870 periods various other instruments were advised to rotate burs in cavities.
Early example of clock wise drill was patented in 1864, come into use by 1871, It was with the advent of the foot engine that the first dental hand pieces came into being.
Straight hand pieces with a variety of intricate chuck-closing mechanisms became well developed during the 1880, and since they were permanently linked to the foot – engine flexible cable were converted into angle hand pieces by connecting so – called " lock – bit attachments" to their front ends, these lock-bits being available in right angle, acute angle and obtuse angle patterns.(Fig 1)

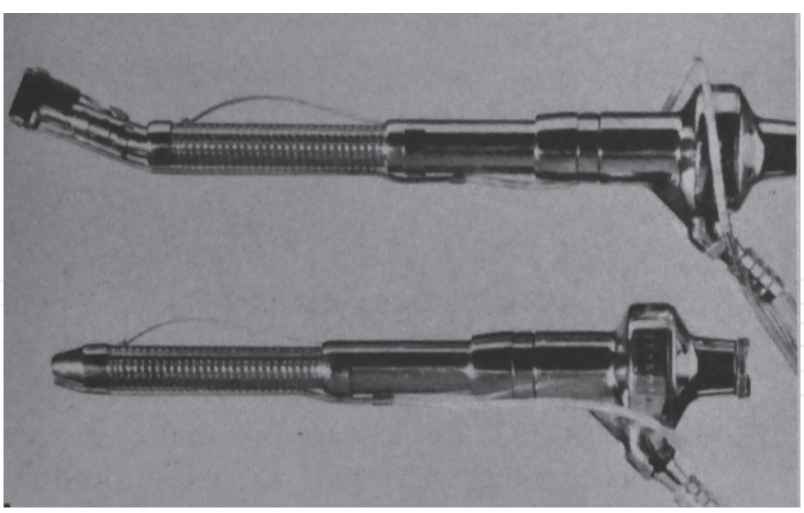

Fig. 1. Dental hand piece in 19th century.

From 1875 onwards, the use of the foot engine became widespread, but its demise was foreshadowed by the advent of electric headpiece driving mechanism.
Early electric motors were designed to be attached to foot engines or alternatively as independent entities.
In briefly, dental hand pieces are small, very specialized air as electric driven turbines used in both high and low speed dental hand pieces.

2. Structure of dental hand piece; turbine

A turbine is typically made up of multiple components including:
Rotor: Integral shaft on which components are mounted
Chuck: usually housed within the rotor.
Impeller: Component which converts energy from pressurized air or electricity in to the rotational motion of the turbine required for cutting.
Bearing: Allow entire assembly to spin freely with as little friction as possible.
Rings: Provide firm seating inside hand piece head while minimizing vibration.
High speed dental hand pieces turn at approximately 400/000 revolutions per minute (rpm).
Slow speed dental hand piece turn at 150 rpm to 2000 rpm.(Fig 2)

Fig. 2. Structure of dental hand piece.

Because of the specialized nature, very high speed, the turbines that drive them must be manufactured to the highest standards. Standard materials would result in imminent failure, and possible harm to the patient on which the equipment was being used.
Hand piece manufacturers sometimes design hand pieces around the mast efficient, highest power producing dental hand piece turbine that current technology allows.
Speed and torque is king where dental hand pieces are concerned and competition is fierce between manufacturers.

3. What is torque?

Torque is a measure of how much force acting on an object cause that object to rotate.
Torque also called moment ox moment of force is 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 oz a fly wheel, for example, pushing oz 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. (Fig 3)

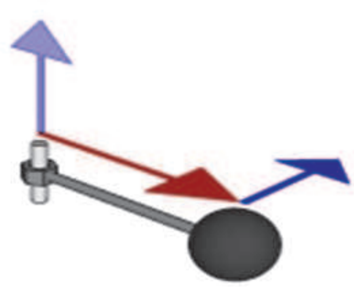

Fig. 3. Turning force.

4. Torque in dentistry; root canal therapy

In many aspect 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.
The 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.

5. Torque control hand pieces

Different types of hand pieces are used in conjunction with the rotary instruments, the air and electric motors without torque control and the electric torque control motors. (Fig 4)

Fig. 4. Torque control motor.

Theoretically, the torque control hand pieces (motors) take into consideration the torque at failure of rotary instrument.
Torque values lower than the torque at fracture of the instruments can be set on the torque control hand pieces.
When a high torque control hand pieces is used the instrument is very active and the incidence of instrument locking and, consequently, deformations and separation would tend to increase.
Air driven hand pieces or air motors do not allow torque control and variation in air pressure could affect the rotational speed and, consequently, torque. For instance a drop in air pressure would lead to a decrease of torque. (Fig 5)
The instrument would become less active, and the operator would tend to force the instrument in to the canal of teeth leading to deformation and separation.

Fig. 5. Air driven hand piece.

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, respectively, 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, thus increasing the mechanical stress and the risk of fractures, it must be emphasized that the elastic limit of the tested instrument was found to be lower than 1 ${}^{N}/_{cm^{2}}$ when subjected to torsional testing.
To limit this potential breakage, a low torque motor should be used , 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 to an extent far below what has been possible before.
With the low torque motor, the motor will stop from rotating and can even reverse the direction of rotate when the instrument is subjected to torque level equal to the torque value set on the motor thus instrument failure would be avoided.

6. Different types of torque control electro motors

NSK Brasseler ENDO-MATE DT, ENDO-MATE DT is specifically designed for use with Ni-Ti files from all major suppliers. User-programmable preset memory can store up to 9 speed and torque settings exactly to the supplier's spec. A compact and lightweight control unit offers convenience of full portability between offices. ENDO-MATE DT can be hooked up directly to wall outlet or used with rechargeable battery. A large LCD display offers higher visibility for instantaneous recognition of micromotor status (Fig 6).

Fig. 6. ENDO-MATE DT.

J Morita root ZX® II low speed handpiece module

Root ZX II can easily be upgraded to a low speed handpiece offering speeds from 150 - 800 rpms. The low speed handpiece module is interchangeable and snaps easily onto the back of the unit. This new versatility allows the clinician to choose between apex locator, low speed handpiece, or a combination of both. Designed for enhanced performance, the tailor-made handpiece is lightweight (70 g) and has a compact head height (12.5 mm). Proven Root ZX II technology delivers extreme accuracy and reliability, while the display screen allows the clinician to visualize file movement during instrumentation (Fig 7).

Fig. 7. J Morita root ZX® II.

J Morita Tri Auto ZX. The Root ZX II low speed handpiece is loaded with automatic safety functions. A new feature, Auto Torque Slow Down, offers added protection when preparing the canal. The file automatically slows down as the torque load approaches its set limit helping to reduce file breakage (Fig. 8).

Fig. 8. J Morita Tri Auto ZX.

The cordless Tri Auto ZX is the only endodontic handpiece with a built-in apex locator, providing the capability and convenience to electronically monitor the root canal before, during and after instrumentation. With the combined technology and accuracy of the Root ZX apex locator, the Tri Auto ZX can significantly increase accuracy and safety. The Tri Auto ZX also offers greater control and flexibility with the adjustable torque settings. The choice of automatic or manual mode operations provide versatility. The three automatic functions include: Auto Start/Stop, Auto Apical Reverse and Auto Torque Reverse.

J Morita rotary master® electric low speed motor

The Rotary Master is a lightweight, ergonomically designed, low speed electric motor with a consistent operating speed, regardless of the load applied to the rotary file. It is a perfect complement to any nickel titanium rotary file system. The Rotary Master comes with a 16:1 contra angle and boasts one of the smallest contra heads on the market. The variable speeds allow the unit to be used for a wide variety of general and endodontic procedures. Other features include a large digital rpm display, touch-panel adjustments and a motor reverse. The 1:1 contra angle and automatic crown and bridge remover are optional (Fig. 9).

Fig. 9. J Morita rotary master® electric low speed motor.

TCM Endo 3The microprocessor controlled TCM Endo III is a slow-speed, electric torque-control motor capable of achieving faster and easier root canal preparation. Speed and maximum torque levels are preselectable and constantly controlled by the TCM III control unit. Speed is constant until the adjusted torque limit is reached, then the motor will reverse for 2 revolutions and return to the forward direction to finish root canal preparation. The TCM III is compatible with both Quantec and K3 Rotary Systems (Fig. 10).

Fig. 10. TCM Endo III.

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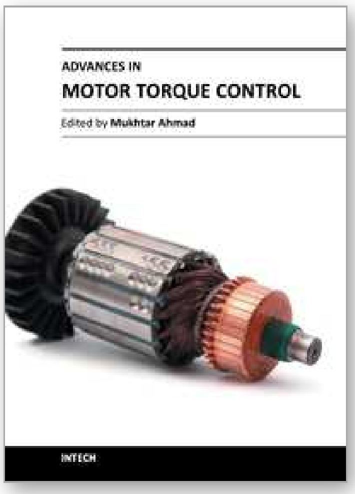

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Electric motors are widely used in industries to convert electrical energy into mechanical form. Control techniques are designed to improve the performance and efficiency of the drive so that large amounts of electrical energy can be saved. This book is primarily written with the objective of providing necessary information on use of electric motors for various applications in industries. During the last ten years a number of methods of control of electric drives have emerged. Some of these methods are described in this book. The reader will be able to understand the new methods of control used in drives, e.g. direct and sensorless control. Also the application of motor control in dentistry, the effect of human reaction and improvement of the efficiency of drives with control have been described.