Cutting Efficiency and Preservation of Canal Curvature in Simulated Curved Canals using Reciprocating and Non-reciprocating Ni-Ti Systems

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بِسۡمِ ٱللَّهِ ٱلرَّحۡمَٰنِ ٱلرَّحِيمِ

" قالوا سبحانك لا علم لنا إلا ما علمتنا إنك أنت العليم الحكيم"

صدق الله العظيم

أية٣٢ من سورة البقرة

Dedication

To the Soul of My Dearest Father

To My Lovely Mother

To my faithful Husband

To my sweet Kids

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Introduction

Uniformly tapering canal with a definite apical seat facilitates the insertion of a hermetic seal is the main aim during root canal cleaning and shaping. Procedural errors such as apical transportation, elbow formation, ledging, strip perforation, perforation and instrument fracture can occur during root canal instrumentation especially in curved root canals. Various techniques and instrument modifications have been introduced to avoid and minimize these errors. A limiting factor in all these techniques has been the excessive stiffness of the larger endodontic file sizes which produces distortion or straightening of the canal during instrumentation.

Files fabricated from nickel-titanium alloy exhibit super elasticity and shape memory characteristic. This allows nickel-titanium files to be superior for the instrumentation of curved root canals than stainless steel files. Following guidelines based on different inherent properties, NiTi rotary systems may achieve final root canal preparations with superior qualities in a safe, simpler and more predictable fashion compared with most traditional methods.

Cutting efficiency is one measure of endodontic instrument evaluation and is dependent upon instrument's dimensional and physical properties which are inherent features of instrument's design and the material from which it is fabricated.

Review of literature

1-Cutting efficiency of endodontic instruments:

Cutting action is the basic functional property of endodontic instruments. Cutting is the ability of an instrument to cut through a given material, while cutting efficiency is the rate by which an instrument can cut through a given material. Cutting efficiency is affected by several factors being a complex interaction of different parameters such as: metallurgical properties, cross sectional configuration of the shaft, sharpness of flute, flute design, tip design, lubrication during cutting, wear resistance, chip removal capability and mode of use. [1]

Yguel et al [2] assessed cutting efficiency via "wear" volume measurement by means of three-dimensional surface mapping on bovine bone serving as a dentin substitute. A high precision method was presented for measurement of root canal instrument cutting efficiency in pure, linear movements. Operator-independent instrumentation was achieved by means of an automatic, mechanical test rig mounted as an accessory in an Instron tensile testing machine . A volume precision of 3 x 10(-3) mm3 was achieved which is equivalent to a weight resolution better than 10 micrograms. In particular, cutting efficiency data for K-type and H-type files was presented showing an enhanced performance (by roughly a factor of 3) in the latter case. Lubrication was also shown to increase the cutting efficiency.

Al-Omari et al [(3)] compared the efficacy of K-files, K-Flex files, Flexo-files, Flex-R files, Hedstrom files and Unifiles in terms of preparation time, instrument failure, loss of canal length and weight loss from a total of 300 simulated root canals of various angles and positions of curvature in clear resin blocks prepared by a linear filing motion and an anticurvature stepback technique. Results showed that preparation with Hedstrom files was significantly quicker than with any other file, while preparation with K-files and K-Flex files took significantly longer. Fracture and deformation of instruments occurred substantially less often with Flex-R and Hedstrom files, but significantly more often with Unifiles. Loss of working distance occurred with all file types, but was significantly greater in canals prepared with K-files. Unifiles and Hedstrom files were responsible for significantly more weight toss than the other files, whilst K-files produced significantly less weight loss. Canals with rough undulating walls were created most often by Hedstrom files and Unifiles.

Tepel et al [(4)] investigated the cutting efficiency of different endodontic hand instruments and the effects of instrumentation on curved canal shape under standardized experimental conditions using an automatic testing device. Cutting efficiency in rotary motion was assessed by determination of the maximum penetration depth of the instruments into a cylindrical canal in a special resin block (size 25 and size 35 instruments). Changes in canal shape were determined by instrumentation of standardized canals (42° curvature). In both sizes tested flexible instruments reached significantly greater maximum penetration depths than conventional reamers or K-files. Changes in the canal shape differed significantly between the different instruments in 13 of the 14 measuring points. After instrumentation with flexible instruments with modified tips there were few undesirable changes in shape.

Camps and Pertot [(5)] compared in vitro, the machining efficiency of four brands of nickel-titanium files and two brands of stainless steel K-type files. Instruments sizes 15 to 40 were tested in a linear motion simulating the clinical motion used to remove a file from the canal. The tips of the loaded files were in contact with a resin block. Results revealed that the load applied increased with file size. An indentation varnish caliper was used to measure the depth of the groove after 100 back-and-forward motions. The stainless steel instruments with a triangular cross-section were more efficient than the stainless steel instruments with a square cross-section. There was a significant discrepancy between the machining ability of the nickel-titanium K files. The Maillefer instruments were the most efficient.

Tepel et al [(6)] investigated the cutting efficiency of 24 different types of endodontic hand instruments, which are primarily designed for a rotary (reaming) working action under standardized conditions. With a computer-driven testing device, resin specimens with simulated cylindrical canals were instrumented using a defined working motion. Maximum penetration depth was the criterion for cutting efficiency. Sample size was 12 instruments for each type and size (#25 and #35). Results showed that Nitinol K-files showed the least cutting efficiency. Stainless steel reamers and especially K-files showed better cutting efficiency than Nitinol K-files. With regard to cutting efficiency, flexible stainless steel instruments were clearly superior to stainless steel reamers and K-files, and especially to Nitinol K-files.

Schafer and Tepel [(7)] tested the cutting efficiency for sizes 25 and 35 stainless steel Hedstrom S and U files from 10 manufacturers, and titanium-alloy Hedstrom S and U files from five manufacturers for linear (filing) motion under standardized conditions. Special plastic samples having well-defined abrasive properties were used as the substrate and constant pressure was applied until the instruments were blunt. The depth of the groove achieved by filing was used to measure cutting efficiency. Results showed Hedstrom files made of stainless steel, made by VDW, gave the best cutting efficiency for sizes 25 and 35. It was concluded that Hedstrom files had better cutting efficiency than S or U files. Likewise, stainless steel files provided better cutting efficiency than instruments made of titanium alloys.

Schäfer [(8)] determined the cutting efficiency of different prototypes made of one well defined stainless-steel alloy. The prototypes had five different cross-sectional shapes (square, triangular, rhomboidal, "S"-shaped, and the cross-sectional design of H-type files) and three different numbers of flutes (16, 24 and 32). Cutting efficiency, both in a rotary and in a linear motion, was assessed by use of two computer-driven testing devices. Results showed that the rhombus shaped prototype with 24 flutes showed the greatest cutting efficiency both in a rotary and in a linear working motion.

Schäfer and Lau [(9)] investigated the cutting efficiency and the effects of instrumentation on curved canal shape of both stainless-steel and nickel-titanium nonstandardized ProFile Series 29 hand instruments and stainless-steel Flexoreamer. Concerning cutting efficiency in rotary motion, the Flexoreamer had significantly greater cutting efficiency than stainless-steel ProFiles and nickel-titanium ProFiles. Changes in the canal shape differed significantly between the different instruments at all measuring points. After instrumentation with Flexoreamers with inclusion of two half-sizes (#17 and #22), there were fewer undesirable changes in canal shape compared with both stainless-steel and nickel-titanium ProFile Series 29 instruments. Results showed that flexible stainless-steel instruments with noncutting tips were superior to the nonstandardized ProFile Series 29 instruments with regard to cutting efficiency and instrumentation of curved canals.

Rapisarda et al [(10)] verified whether nitridation treatment of the cutting surfaces resulted in surface or subsurface changes that produced an increase in the resistance to wear in nickel titanium (NiTi) endodontic files. Some experimental samples were exposed to ionic implantation by using 150 keV of nitrogen ions and doses of 1×10^{17} ions per cm^2. Other samples were exposed to thermal nitridation processes performed for 480 minutes at 500°C temperature. Control samples were not exposed to any process. The chemical composition of the surface layers of each sample was determined by means of x-ray photoelectron spectroscopy. The cutting efficiency was tested on an endotraining bloc. Results of the experimental instruments