Section IV. Mastering Future developments

The purpose of the previous sections was to examine the factors that cause file designs and techniques to be attributes or liabilities, successes or failures, and to determine if modifying techniques and the selection of existing instruments could improve the results of instrumentation. As one follows the sequence of thoughts during this process, the question that comes to mind is: "What constitutes a more ideal file design and is there an ideal technique?"

The ultimate purpose of this book is to help provide the means to advance the development of new root canal preparation modalities. Since the clinician is the only one who has first-hand knowledge of what problems exists, he or she needs the framework of understanding to personally become involved in the development of instruments or to guide manufacturers toward progress. The future of endodontic instrumentation cannot afford to rely on intuitive ideas that might or might not result in advancement. Just as instrumentation expertise relies on the understanding of rudimentary concepts of physics, so do advancements in root canal instrument developments. At the very least, clinicians need to thoroughly understand the instruments and the consequences of how they are used.

54. What improvements are being implemented to facilitate instrumentation?

Presently, we see improvements occurring in three areas:
(1) One improvement discussed extensively in this book, is the approach undertaken in the selection and use of the most appropriate instruments for particular tasks that are currently available. Dentists are beginning to question routine cookbook type procedures and attempting to look for answers.
(2) Manufacturers have begun to incorporate design changes to minimize the stress of blade engagement.
(3) And, to a limited extent, we are beginning to see new materials available for enhancing the properties of files and new manufacturing processes for fabricating designs.

Regrettably, the progress for innovative design changes is hindered by the aggressive defense of questionable patented intellectual property and marketing resistance for new product introductions. Nevertheless, new file designs incorporating the potential improvements discussed earlier have been found to have significant advantages for the reduction of the stresses of instrumentation and are finally becoming available to the profession.

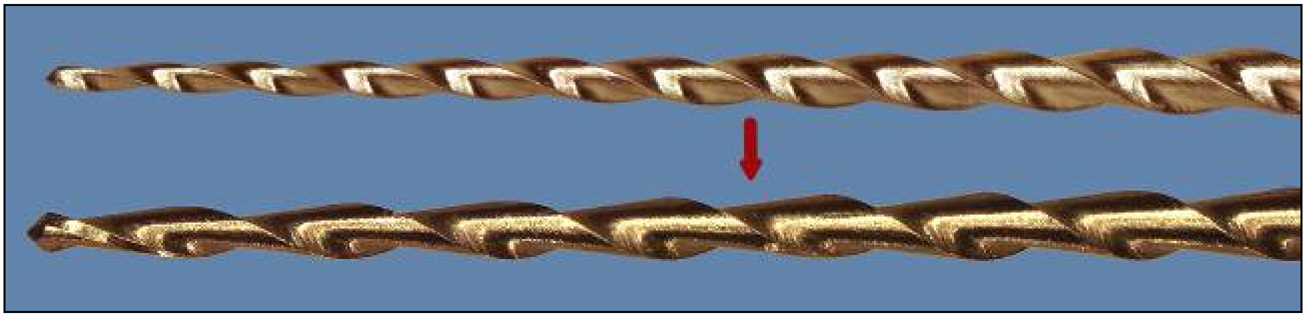
55. What instrument designs reduce the use of excessive stress?

Research is the most useful tool for gaining insight into realms beyond the reach of ordinary perception and experience. In examining the results of current research, trends become apparent for formulating instrumentation designs and techniques. The primary consideration is to set parameters for preventing file failure and eliminating unnecessary or counterproductive procedures. By observing the situations that usually have a high incidence of file failure; we can then test designs and procedures to effectively avoid those situations. Once results are examined, then modifications can be incorporated to achieve the most optimum means of instrumentation. Comparing the features of new instruments, as they are introduced with stress reducing designs, can be an indication of the merits of change. Testing indicates instrumentation should encompass as many of the following considerations as practical, for safe and effective rotary instrumentation:

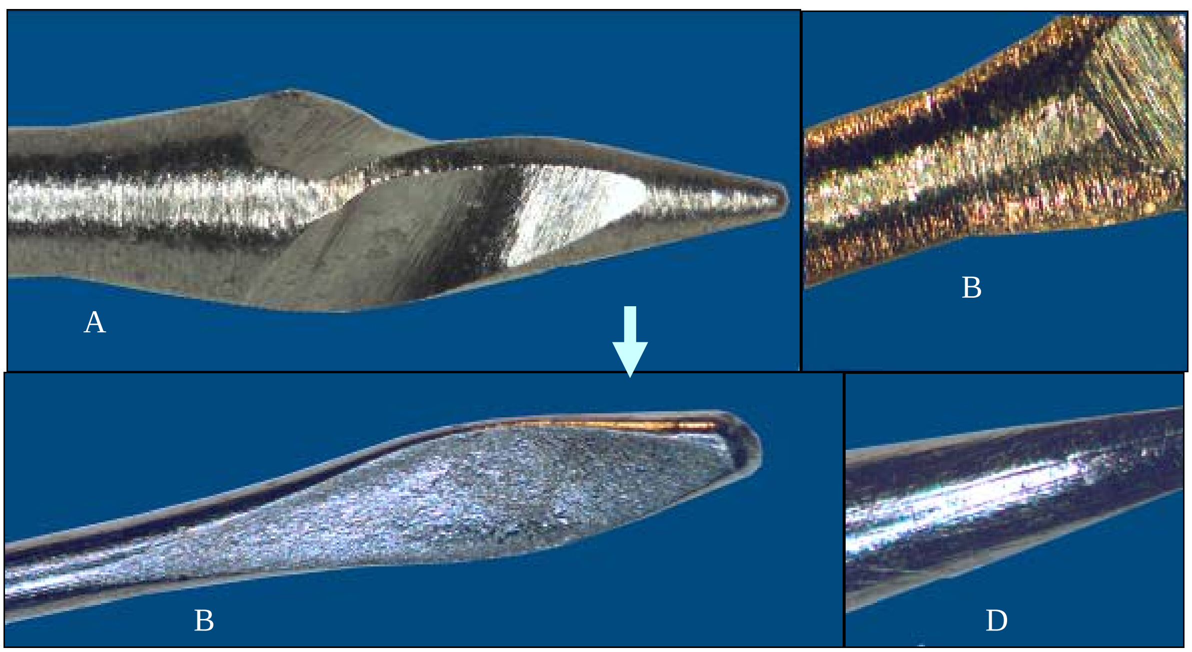
1. Incorporate positive cutting angles to enhance the efficiency of canal enlargement.
2. Minimize any land width or use regressive lands to reduce abrasion on the canal surface.
3. Provide an asymmetrical cross-section to the file to aid in maintaining the central axis of the canal.
4. Reduce file engagement and screwing in forces by reducing, eliminating or interrupting-+ the number of flute spirals to the smallest number necessary while preventing excessive torque that results from the accumulation of debris.
5. Reduce the distance between the minimum diameter and the maximum diameter in order that the torque required for rotating a fully engaged working surface is not greater than that needed to exceed the ultimate strength of any part of the file.
6. Reduce the difference between the file's minimum diameter and maximum diameter so the torque required for rotating the larger diameter is not greater than the torque which would cause the smaller diameter to be distorted beyond its plastic limit.
7. Provide a zero taper or nearly parallel portion of the file, so the apical portion of the canal can be enlarged without the need for large diameters of the file to rotate in canal curvatures that cause undue file stress and canal transportation.
8. Adjust the shaft diameter so potential breakage would occur near the file handle in order to make it more accessible for removal.
9. Utilize a technique to complete the file function before the file flutes fill with debris.
10. Interrupt the continuity of blade engagement with intersecting grooves or by providing an undulating core axis or file profile to reduce total blade engagement.
11. Reduce blade engagement and land abrasion by utilizing different flute and outside tapers in the same instrument.
12. Reduce the number of flutes having similar helix angles. Dissimilar helix angles reduce the screwing-in forces. Flutes with no helix angles eliminate screwing-in forces.
13. Provide a file surface that exhibits greater lubricity to reduce frictional resistance and facilitate debris removal.
14. Provide a file surface that has reduced micro-grooves that cause stress concentration points for potential crack propagation.
15. Provide a design that avoids abrupt changes in design configurations in order to reduce stress concentration points.
16. Provide blades that are appendages or projections from the file shaft instead of blades that result from grinding a groove into the shaft.
17. Provide channels along the long axis of the file to facilitate by-passing the file and its removal if breakage should occur.

56. What stress reducing design changes have been incorporated as improvements on initial designs or can readily be incorporated in files as attempts for improvement?

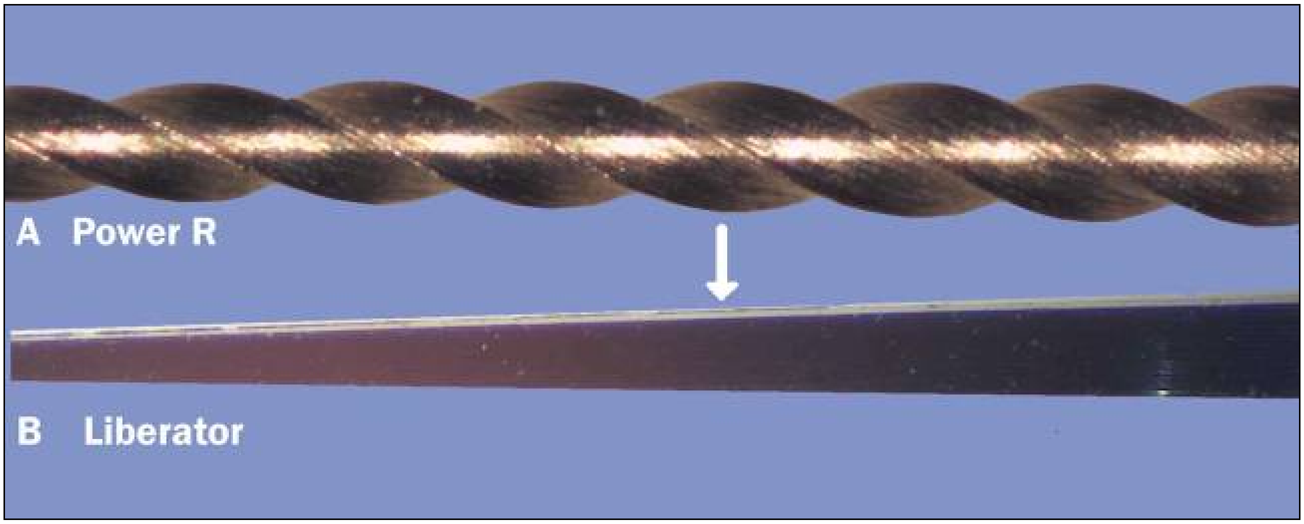
The purpose of the following illustrations, of how files have or might be modified to enhance their function and safety, even though they may never reach production, is to stimulate greater operator interest in file and technique improvement. The greatest untapped resource for file and technique design very possibly is the dentist himself or herself. File modifications that have incorporated stress reduction features include the Hero file change to the Apical file, the Light Speed file change to LSX file, and the Power-R file to the Liberator.



Micro-Mega increased the efficiency of the three fluted H-type file design by incorporating the stress reducing features of reducing the number spirals to reduce blade engagement and by increasing flute depth for more effective debris removal. Also the cutting edges are not as heavily polished and are sharper.



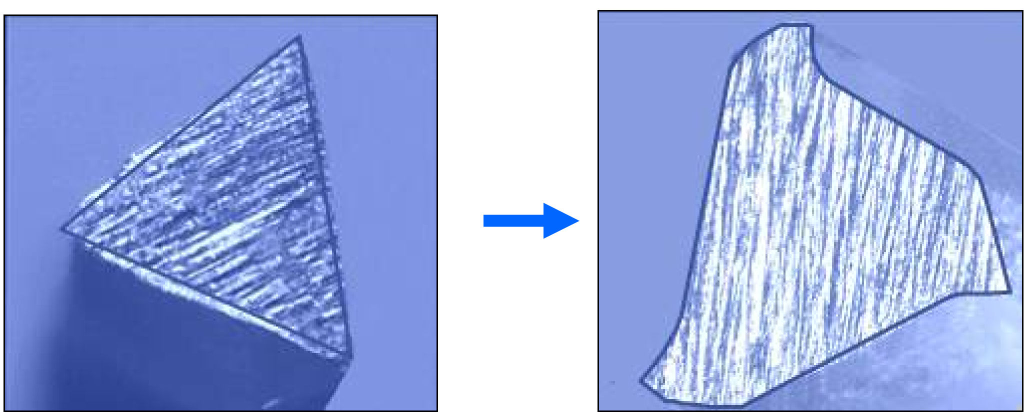
The Light Speed file (A) has been replaced with the LSX (B). The new design is stamped on extruded wire (D) rather than being ground which eliminates the surface micro-grooves (B) that contribute to fatigue. The cutting edge is more positive, engagement is reduced by eliminating spirals, and by-passing the file is facilitated. The new Light Speed design, the LSX, is formed by compressing an extruded NiTi wire by striking its surface to form two flat flutes adjacent to its tip. The advantage of this design is its increased flexibility and the elimination of the circumferential faults that *were more likely to cause fatigue and torsion failure. Its disadvantage is its reduced debris removal ability as a result of the elimination of spirals.*



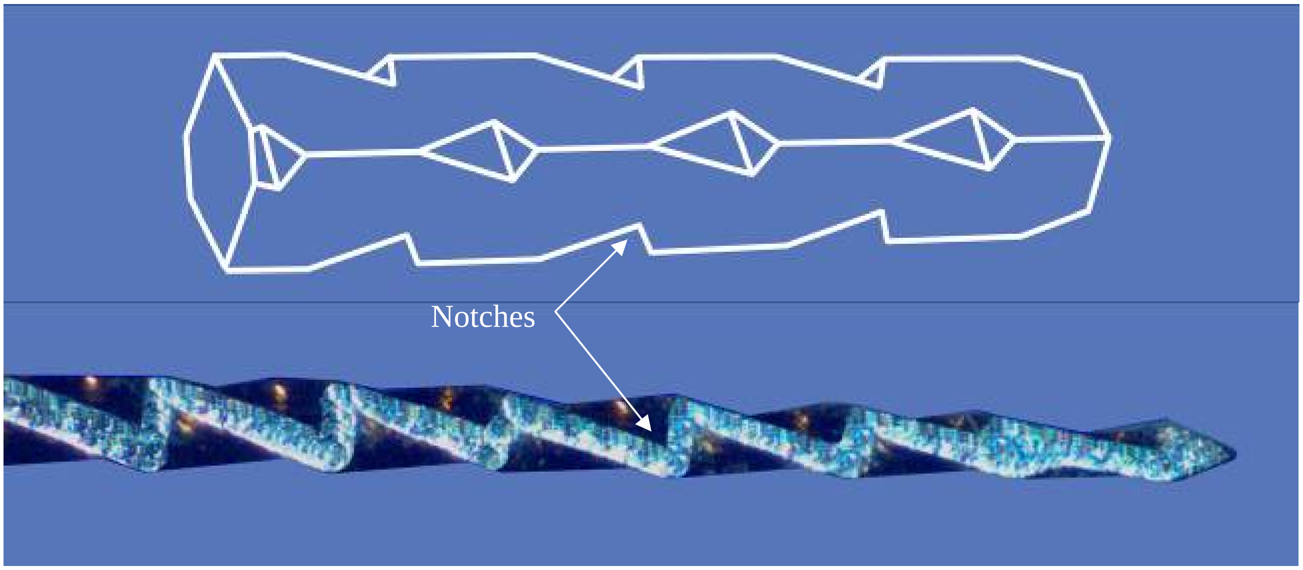
The Power R file (A) has been superseded with the Liberator file(B). Engagement has been reduced and screwing-in forces have been eliminated by incorporating no spirals.

If one wanted take the Liberator file as an example exercise for incorporating more potential stress reducing features, the first step might include increasing efficiency and limiting engagement by:

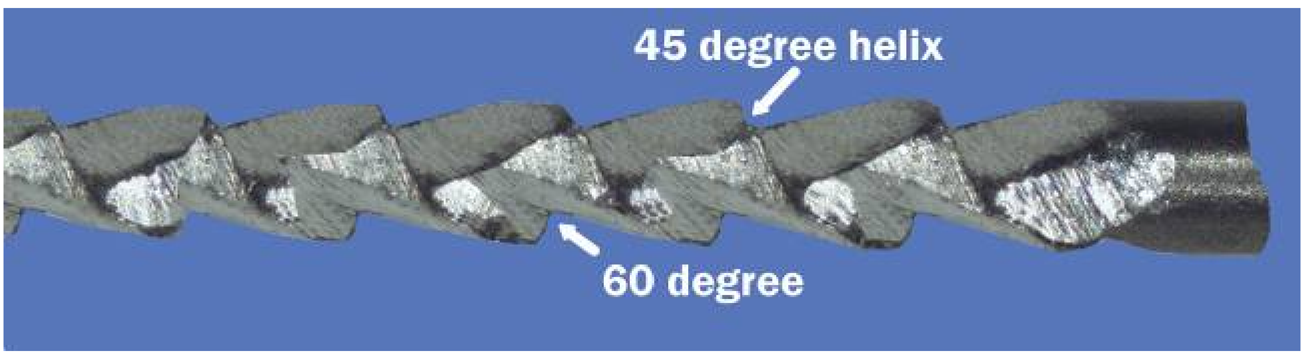
(1.) Providing more positive cutting angles.



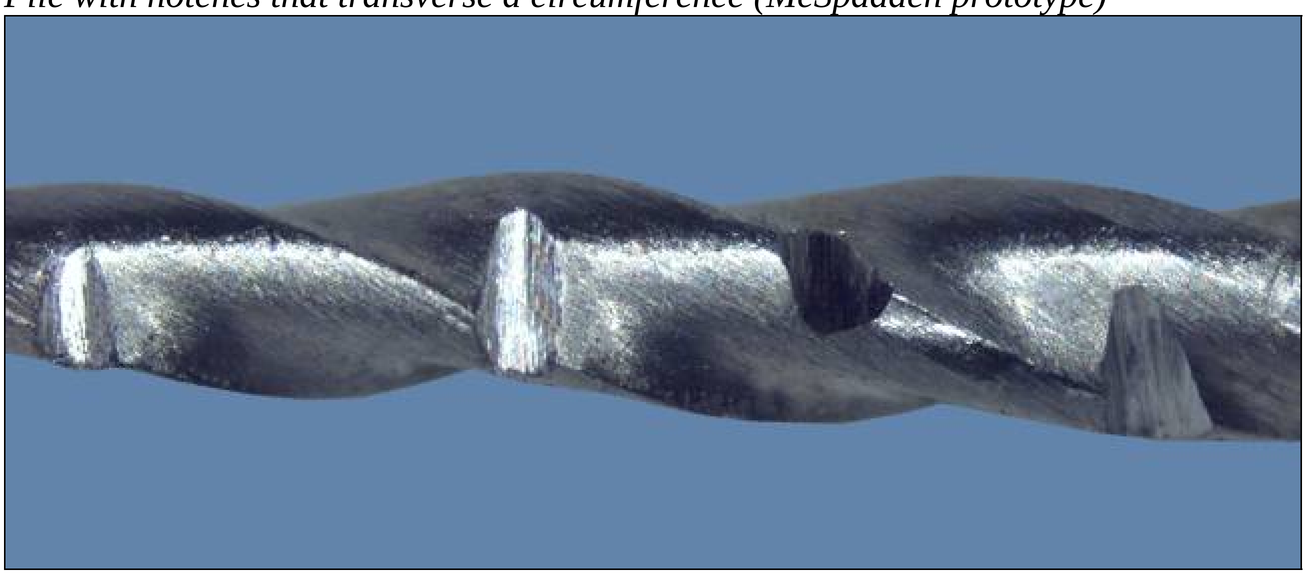
(2.) Providing "notches" that can be ground across the corners of the non-spiraled file or a round tapered wire to result in less engagement, more efficient cutting, greater flexibility, and enhanced debris removal. The notches can be cut at different angles to reduce screwing-in forces and to break up the chips for easier removal.



File with notches that transverse a corner (McSpadden prototype)



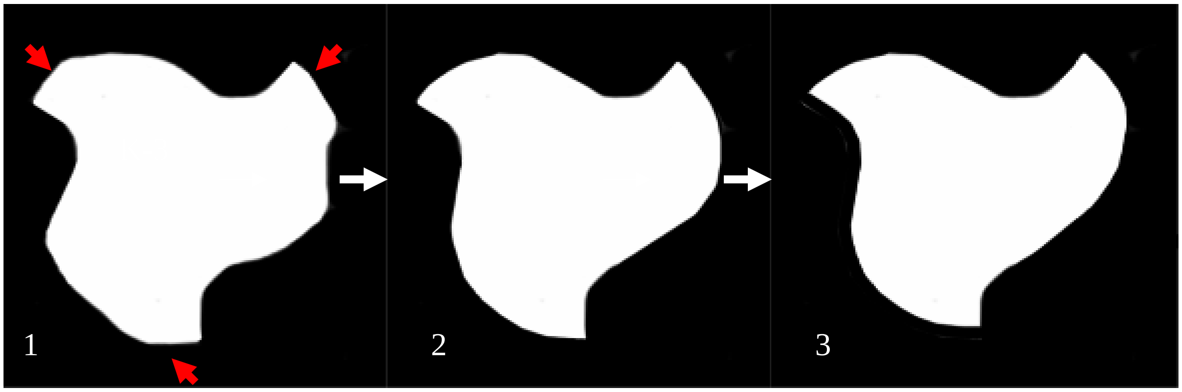
File with notches that transverse a circumference (McSpadden prototype)



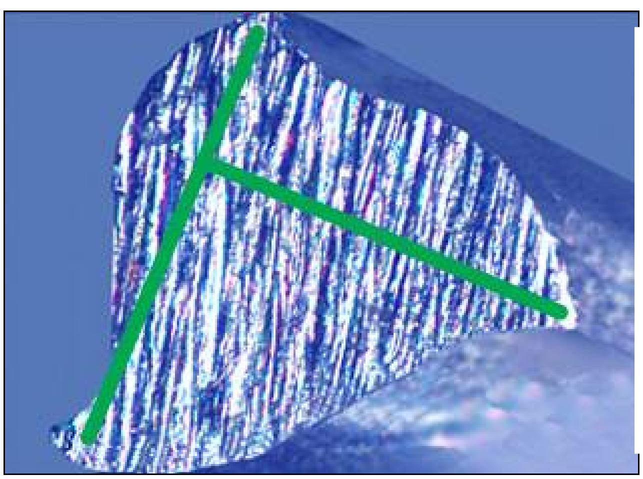
File with notches that transverse a spiral (McSpadden prototype)

56. How can the more complex designs of files be improved for stress reduction?

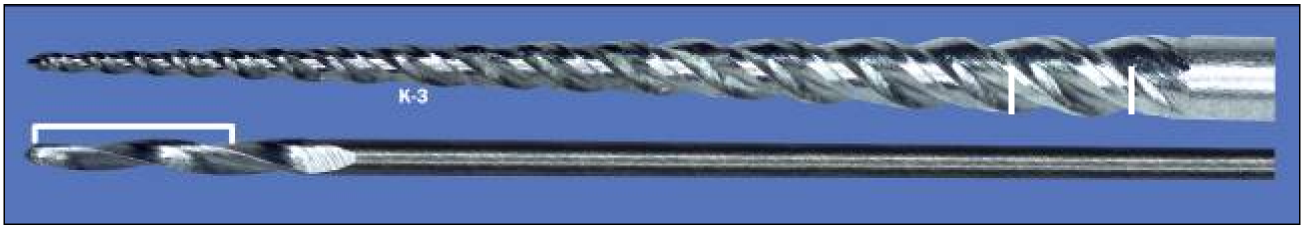
Most would agree that the K-3 file design is the most complex file design available at the time of this writing. The complexity is the result of incorporating positive cutting angles, lands, and asymmetry into its design. Consequentially, the K-3 design is an excellent example to illustrate how applying stress reduction design changes to prototypes can enhance its performance and simplify its use. Each design feature listed above will be considered and applied individually to the K-3 design if appropriate and the design evolution for potential introduction will be illustrated as follows:



The cross-section design. *While retaining the positive cutting angles of the K-3, in image 1, the design of the cross-section is enhanced by first replacing the lands indicated with the red arrows with the recessive lands in image 2. Although lands are especially effective in supporting the edge of the cutting angle and reducing canal transportation, recessive lands significantly reduce the lands' torsion of abrasion. In order to compensate for any potential increased propensity for transportation, the asymmetry of the design is augmented in image 3. The resulting design also provides an undulating core and greater flexibility.*



The asymmetrical 3- fluted cross-section design has unequally spaced flutes to reduce the tendency for canal transportation and recessive surfaces instead of lands to reduce frictional abrasion while engaging the wall of the canal.



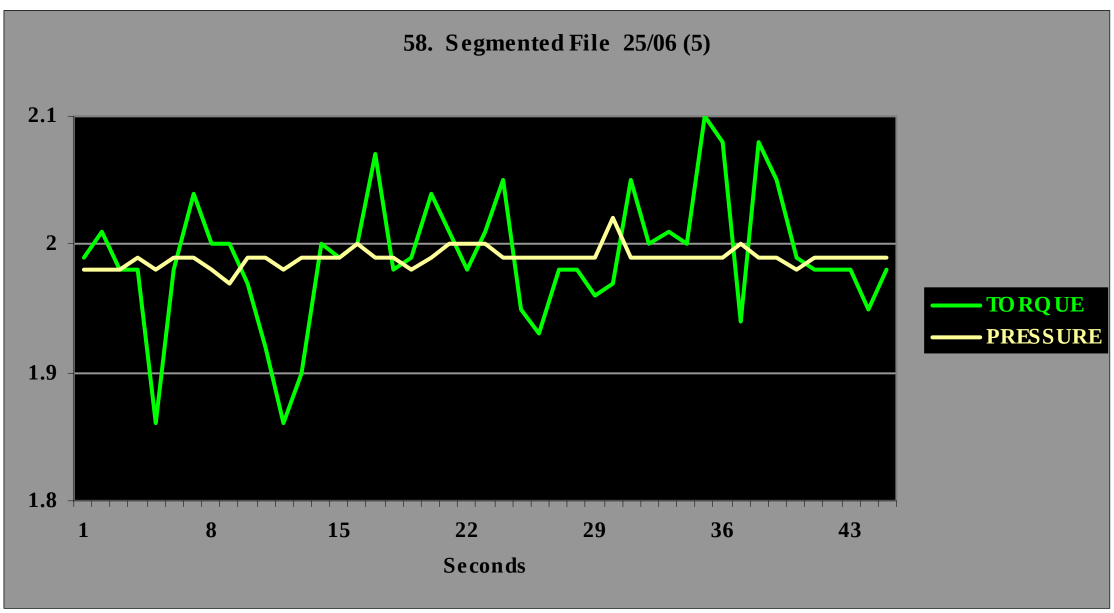
The longitudinal design. *Once the cross-section design changes are redesigned, several longitudinal changes can be incorporated simultaneously. Blade spirals, per unit length, can be reduced. The distance between the maximum and minimum diameters can be reduced, indicated by the white lines. The difference between the maximum and minimum diameters can be reduced. A zero taper can be provided on the file portion not to be engaged in order to provide greater flexibility.*

The segmented approach for canal enlargement. Once the file design changes for reducing stress are incorporated, design dimensions can be calculated for a more efficient and stress reducing technique. Rather than dividing the canal into zones, for reducing the stresses of instrumentation, as described in the previous section, the same result can be simplified by dividing the working surface of a file into sections, corresponding to the section of the canal to be prepared. As was illustrated in the previous section, the most efficient and least stressful use of files requires calculating what part of the file will be engaged, and the regimented steps of crown down and step back techniques may not provide the best means for reducing the chance for failure. The ***Segmented File*** concept is the first file series to limit the stress the file encounters, by limiting its blade engagement, relative to the demands of the canal anatomy. Rather than arriving at a final canal shape by using a series of instruments that gradually changes the shape of the total canal, by using a series of different file tapers and sizes, each segment of the canal's length is essentially prepared to its final shape with one instrument. The file design and dimensions can be specifically fabricated for the length and diameter of each particular canal section and the total canal shape is made up of a composite of segments. For instance, by reducing the length of the file's working surface and reducing the flute spirals, the engagement of the more vulnerable smaller file diameters is limited. As the size of each file segment becomes smaller in diameter, its tapered working surface is reduced and its overall length is increased.

The positions of stops are measured from the handle end rather than from the tip.

Segmented Series*. Appropriate to its diameter, the tapered working surface of each file is limited to reduce the stress of engagement. As the size of each file in the series becomes larger in diameter, the length of the file becomes shorter by the length of the previous file's tapered working surface. The example segmented series above illustrates how a 25/06 conventional file can be divided into four .06 tapered segments in order to limit the potential stresses on the file. The most coronal portion of the file does not have a segment since an orifice opener would incorporate that portion of the preparation. The maximum and minimum diameters of each file slightly overlap those of its adjacent segment, but the file does not have to be used in any sequence.*
The files can be used in any sequence since its total engagement will be limited to the length of its working surface.

The canal can be prepared using a crown-down, step-back, or any sequence to result in a continuous taper (with each file assuming the preparation where the previous file ended it or at a position appropriate to that section of the canal). The final preparation results as a composite of segment preparations that equals the desired final shape of the canal.
By using this approach, only a minimum number of files need to be used and excessive stress on any of the files can easily be prevented. Having smaller maximum diameters, proportionally less cross-section areas per diameter, and smaller shafts, enhances the flexibility of the files for mid-root and apical preparations. The area of the working surface is limited and there is little difference between the minimum diameter and maximum diameter on each file. Consequently, the torque necessary to rotate the maximum diameter or the total working surface is not enough to cause failure in the tip portion of the file.



The above graph charts the torque that was generated, during which a 25/06 Segmented File with a maximum diameter of .45 mm was inserted into a size .20 mm diameter canal, prepared by a 35/06 Segmented File, and extended the preparation an additional 3mm. The maximum torque generated was 14.3 gm-cm. This unusually low torque resulted because the amount of engagement was limited to the 3mm tapered portion of the instrument.

As an added advantage, the tapered working surface of each segmented file is followed by a parallel or reversed tapered shaft that may or may not be fluted; therefore, the smaller mid-root and coronal shaft diameters facilitate negotiating curvatures and reduce the tendency for straightening the canal. In using each file, the recommendation still follows that no additional pressure, greater than the initial pressure that was required to advance the file into the canal, should be exceeded. In addition to reducing the blade engagement by shortening the working length, the blade design has been modified to minimize engagement, as well as enhance efficiency and flexibility, by using an asymmetrical 3-fluted H-type cross-section.

To reiterate the introduction of this chapter, the ultimate purpose of this book is to help provide the means to advance the development of new root canal preparation modalities. Since the clinician is the only one who has first-hand knowledge of what problems exists, with the framework of understanding provided in this book, he or she needs to personally become involved in the development of instruments or to guide manufacturers toward advancing improvements.

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