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John McSpadden - Scientific Evidence vs. Intuitive Impressions
The Zone Technique

Much of the information we receive about endodontic instrumentation is limited to step by step techniques. By not understanding the "why" and "how" we place ourselves in the position of having to rely on what a particular Guru, article or trial and error – which can be costly. Most of the answers can be found in physics. McSpadden feels that we don't apply physics to the science of canal preparation, yet we spend most our time trying to overcome the problems of instrumentation. He also says that there is the impression in endodontics that in order to do better treatment – we have to work longer or harder. McSpadden suggests that the both a complex canal and a single canal can be handled similarly- IF we understand how to use the instruments. When we can reduce the stress on the instruments – things should be EASIER – not harder.

What causes instrument breakage? - What does science tell us?

Canals are a "system". These canal systems cannot be done with a step by step procedure that ignores their inherent complexity.

Two things cause instrument breakage:

1. **Fatigue** - the excessive stresses of the repetitive compression and tension that occurs during rotation of a file around a curvature
2. **Torsion** – the axial force of being twisted when one part of a file rotates at a different rate than another part

The Rules of Physics in Relation to Files

1. **Fatigue of a file increases with the square of the diameter of the instrument – the bigger the instrument the more it will fatigue.** E.g./ a size 40 instrument is 4X more likely to fatigue than a size 20 instrument (half the size)

McSpadden showed video of a # 25 - .02 file that was rotated in a glass tube and it broke when the file was inserted to the point where the thickest part of the file flutes entered the tube (size .57 where the flutes end). This occurred because of 2 reasons: - The Fatigue (Diameter) rule as above AND the stress concentration of the flutes ending at the instrument shaft.
He then showed another rotary file .06 taper rotated in the same glass tube – it broke where the file was a diameter of .55.
McSpadden then showed a radiograph with a tooth that had a 90 degree bend at about 6 mm from the apex. It looked very much like the glass tube in shape. He then said that if you followed the manufacturers step by step method – you'd be likely to insert a #20/.06 to length (as recommended) but the instrument diameter would be .56 at the curve and you'd be risking breakage. SO we must UNDERSTAND THE MATH behind the method! Don't indiscriminately carry file to working length unless you know the XYZ axis.

McSpadden has done extensive research using teeth with a 45 degree bend and an 8mm radius of curve. This is not an unusual curvature for a tooth. He has done many experiments with this and these are his findings. (He emphasized that each canal is different and that this rule is not firm with respect to absolute size):

45 degree curve – 8 mm radius – Fractures @	
Size .60	.02 taper instrument
Size .55	.04 taper instrument
Size .50	.06 taper instrument
Size .35	.08 taper instrument

2. **The greater the taper, the more the force is concentrated in a smaller area and the greater the potential for fatigue!** This is very important in how we approach teeth with different anatomy.

3. Fatigue of a file increases with the **degree of curvature of the canal, length of the radius** and the **number of rotations,** The longer we stay in the canal with the instrument rotating, the more likely it is to break. These must be factored into the technique

4. The ability of the file to resist TORSION is related to the **square of the diameter.** (The opposite of fatigue!) The larger the file – the greater resistance to TORSIONAL breakage. E.g. / a size 50 instrument is 4x less likely to break from torsional failure then a size 25 instrument.

McSpadden then showed a video with a file penetrating a plastic block. The middle section of the block was ground away so that only the coronal and apical sections of the block were present. The file initially engaged the thicker coronal section but once it then also engaged the apical section – it broke INSTANTLY. The torque required to make the coronal aspect cut was much larger than the torque required to break the tip. Clinical relevance? -> If you are working the coronal aspect of the canal AND the tip engages in an accessory canal, fin or bifurcation – it can easily break the tip without warning. The problem with torque limiting headpieces is that they don't know WHERE the torque is being exerted on the file.

5. The torque required to rotate a file varies directly with the **surface area of the file's engagement in the canal.** Engagement is relative to the diameter and length of the instrument that contacts the canal walls. The greater the engagement – the more stress we put of the instrument. With sufficient engagement, the file will "untwist" and eventually break.

How much of the instrument can we engage in the canal?

6. **Do not engage more than 6 mm of the file's working surface** if the file is engaged in a curvature (except for .02 tapered files having a size diameter of .20 mm and smaller)

Dr. McSpadden has used Ni-Ti longer than anyone. He admitted his commercial interest in Kerr/Sybron instruments but he said his commercial interest was incidental. He knows of no technique that places this restriction on instrument use.

He then showed what happens when using a 25/.06 instrument followed by a 25/.04 instrument. Initially the 25.04 has minimal engagement (only at the tip) BUT advancing the file apically only 1 mm engages 3 mm of the file. If you advance the file 2 mm you engage 7 mm of the instrument – violating our "6mm engagement rule". But how many techniques advocate NOT advancing more than 2 mm than the previous file – virtually none?!!

Engagement for 2 mm of advancement (instruments with same size tip)	
.08 to .06	8 mm
.06 to .04	7 mm
.08 to .04	5 mm
.04 to .02	5 mm
.06 to .02	4 mm
.08 to .02	3 mm
ProTaper S1 to S2	10 mm
S2 to F1	12 mm
F1 to F2	13 mm
LS to LS	Working surface
35/.04 to 30/.04	TOTAL engagement

So if you use with constant taper set of instruments with a Crown Down technique and move down the canal by using progressively smaller tips – you risk maximum engagement of the entire file with each placement – once the file has reached the maximum working depth – RISKY!

This is the reason for graduating or varying tapers is that if you introduce these files into the canal (since they are larger than the diameter of the canal).- they will engage only a small part of the coronal aspect of the canal at first and NOT have the problem of full file length engagement.

7. **Advance an instrument into the canal with no more than 1 mm increments with insert/withdraw motions** (at least ½ mm per second) As you advance down the canal in increments – you relieve the stress on the instrument. If you do it as one continuous downward focused motion you can generate huge stresses (20 x as much!) on the instrument that virtually guarantee its breakage.
8. **A file with a more efficient cutting design requires less torque, less pressure and less time to accomplish root canal enlargement.** The efficiency of an instrument also is related to its (1) side cutting ability and (2) circumferential cutting ability. There is a difference between the two depending on the design of the instrument.
   Cutting (rake) angles – described as positive or negative. Positive angles are much more efficient than negative angles. It is important to understand this because if it is going to cut more you want to apply LESS pressure to the instrument and stay in the canal LESS time. He showed cross sections of K3 and ProTaper and said that if you push on the K3 like you did when you use the ProTaper –

you might break the K3. i.e. / Different instrument-> Different cutting characteristics –> different "touch" required to use it.

McSpadden then went on to show cross sections of the Hero, Profile/Profile GT, Sequence, ProTaper, Quantec and K3.

Some instruments have flat surface ground in their cutting edges called lands (Profile/Profile GT, Quantec, and K3). The function of the land is to limit the cut and keep the file centered in the canal.

Tests of Side Cutting Ability - with these instruments. McSpadden showed a device he constructed that allowed him to measure and compare the side cutting ability of the files. The files were rotated up against a plastic sheet with a predetermined speed and force (2 lbs of pressure at the 9 mm file level for 30 secs @ 300 rpm). The depth of the cut in the plastic was then measured as used as measure of cutting ability.

Dr. McSpadden showed the various videos of each of the instruments cutting the plastic and stated that he wanted to show scientific proof of his claims not just base his claims on opinion. He implied that too often perception or opinion is offered by those who don't have the science to back them up.

Results – Cutting Depth @ 30 seconds	
Profile GT	28 mm
Profile	32 mm
Hero	34 mm
ProTaper	61 mm
RaCe	91 mm
Quantec	1.22 mm
K3	2.47 mm

What about penetration? How can we use the side cutting ability in this manner when 360 degrees engages? (The less of the instrument that you have engaged, the higher the speed you can use and the greater the efficiency will be. That is why LightSpeed instruments are used at 2000 rpm – they have very little engagement so they can be turned quickly.)

Therefore if you are only engaging 180 degrees of a rotary file – you can increase the speed (to maximize efficiency) – AS LONG AS THE TIP DOES NOT ENGAGE AND REMAINS PASSIVE. Example / McSpadden uses K3s at 1200 rpm (instead of 300 rpm) ONLY IF HE IS ENGAGING THE SIDE OF THE INSTRUMENT. This can be very useful when you are in the coronal aspect and are combining canals that have an isthmus or are ribbon shaped.

McSpadden then did similar tests in canals using a "Circumferential Torque test" as instruments were advanced when engaged 360 degrees in a simulated canal. The Model he used was this: 300 rpm, instrument advanced 1 mm/second in a 4 mm length simulated canal of .70 mm diameter – enlarged to a size 1.15 mm diameter. Engage the file to the largest diameter of the instrument and measure the torque generated. (GT to size 100- its largest diameter and RaCe to size 73 – its largest diameter. Therefore GT and RaCe will have less inherent torque by virtue of less instrument size)

Torque at Max Diameter	
ProTaper SX	348 gm cm
ProTaper S1	195 gm cm
ProFile 20/06	161 gm cm
ProFile GT 20/06	96 gm cm (size 100)
K3	110 gm cm
Quantec	59 gm cm
RaCe	52 gm cm (size 73)

<u>SO? What are the Instruments and Techniques that he uses?</u>

<u>Instruments</u>

According to his studies – McSpadden uses:
(1) Quantec files for circumferential engagement and
(2) K3 for side engagement

<u>Technique</u> – the Zone Technique

The zone technique takes into consideration:
(1) what the instrument diameters should be while they go around a curve
(2) we should not engage the instrument more than 6 mm if any part of it is engaged in a curve

In order to use the Zone technique McSpadden says we MUST know about the anatomy. We should have a rough idea of the canal curvature AND how far the curves are from the instrument tips so that we don't violate the Zone rules.

Example : 45 degree curve – 8 mm radius – Fractures @	
Size .60	.02 taper instrument
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Size .50	.06 taper instrument
Size .35	.08 taper instrument

He believes that finding the POSITION of the curvature is just as important as finding working length. Because the anatomy of the tooth dictates how you can efficiently enlarge and shape the canal. Otherwise you will be inefficient and need to constantly recapitulate with series of files to do the same work.
For example – If he uses a 15/.02 to length and then tries to place the file in the canal again by hand AND it meets resistance – that indicates a curve. McSpadden records this just like a WL measurement. He refers to the area beyond the curvature as the "The Apical Zone". The area above the curvature is referred to as the "Coronal Zone".

McMath – The Apical Zone

$$\frac{\text{Limitation of the Diameter (-) Tip Size}}{\text{Taper}} = \text{Length of File that can be advanced into the apical zone}$$

Example case:
If we are using a 25/06 instrument. How far can we carry that instrument down the canal if we meet a curve? We said in the above chart (a canal with 45 deg. curve 8 mm radius) that for a .06 taper instrument the file diameter should be no larger than .50 for safe use. Therefore:

$$\frac{\text{(Diameter limit of .50) MINUS (tip size of .25)}}{.06} = 4 \text{ mm}$$

4 mm is maximum safe advancement of the file according to what we perceive is the curve of this canal.

What if the canal is MORE curved than that? How can we tell? If you know that you have had a 15/02 (for example) at WL and when you try to reinsert it – it has resistance. How hard you have to PUSH the instrument to get it around the curve will give you an idea of how much of a curve there is. The resistance perceived in that case is not the canal walls – it is the instrument resisting BENDING. More resistance = greater curve. That takes practice to appreciate and perceive.

But what do most of the "standard" techniques recommend? -> carry the instrument to the full working length!! They also recommend extreme caution, recapitulation and frequent hand instrumentation. McSpadden says that this is because they don't know what they are doing.

The Coronal Zone – Implications when working in the Apical Zone

Remember- we need to enlarge the coronal zone so that no file will bind in this area when the file is used in the apical zone. The coronal zone must be made large enough to accommodate the instrument without engaging BOTH zones at the same time.
Example/
In the previous case with the 25/06 instrument - we have advanced the instrument in the apical zone – 4 mm into the canal. 4 mm BACK from the tip of this instrument the file is .49 mm in diameter. (.25 tip size + (.06 taper x 4mm) = .49 at D4) Therefore for the file to be clear of Coronal obstruction we must

have the coronal aspect enlarged to at least a size 50 to allow for free apical movement of the file without coronal zone contact. That way we don't engage more instrument than we want. (The only exception is .02 tapered instruments.)

The Zone Technique – What is it?

1. We want to change tapers with every instrument that we use (Limits engagement)
2. We want to advance apically no more than 1 mm at time in 1 mm increments. We should not have to increase the pressure on the instrument to do that. If you cannot make ½ mm/sec advancement – you are using the wrong instrument – get out of the canal
3. Limit diameter in the canal - 60 for .02 taper, 55 for .04, 50 for .06, and 35 for .08. Figure out which instrument you use by using McMath.
4. Limit area of contact to 6 mm maximum engagement

McSpadden doesn't care if you use crown down, step back or skip instruments. As long as you observe these rules you are not likely to get into trouble. McSpadden's personal Zone technique - Quantec for penetration - K3 for side cutting.

Just before closing, McSpadden raised an interesting issue. He said that there was a perception in endodontics that doing a better job required more time and he questioned whether that was so. (He used the example of taking 5 tries to thread a needle vs. one try – which was better?) McSpadden estimated the actual amount of canal length that would have to be engaged by a file and then figured out how long it would take using the ½ mm/sec or 1mm/sec advancement rule. In a 20 mm tooth, with efficient use of the right instruments he believed it was possible to easily instrument a molar (regardless of complexity) in 15 minutes. It simply involved knowing how and what instrument to use in an efficient manner and NOT trying to use cookbook methods that were inefficient and not understood by the operator.