Endodontic success and working length: thinking 5-dimensionally

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I
n the article Endodontic success: it’s all about the apical third (Endo Tribune, March 2008, pages 8-11), we introduced the term working length (WL). Don’t be surprised if you have never heard this term — it’s quite new. We defined WL as the distance from the apex to the coronal working length. WL is the canal’s preinstrumented diameter, adjacent and coronal to the apical constriction (Fig. 1). I like this term very much, because it is a valuable reminder that WL includes the apical dimension. Instrumentation should address a working length and a working width. My last article focused on working width, this article focuses on working length.

Definition of working length

There is considerable disagreement regarding exactly where working length (WL) should terminate. Let’s explore this reasoning from the perspective of each of it all. The American Association of Endodontists’ Glossary of Endodontic Terms states: “working length is the distance from a coronal reference point to the point at which canal preparation and obturation should terminate.”1 Where is the disagreement? The definition doesn’t tell us where WL should terminate. Exactly where should it be? Our forefathers hotly debated the question for many years, and the issue appeared to be resolved. Unfortunately, WL is once again embroiled in controversy.

Our forefathers concluded that instrumentation should end at the cementoenamel junction (CDJ) (Fig. 1), which is approximately colocated with the apical constriction. Most agree with that location, because the pulp makes dentin and the periodontium makes cementum. Instrumentation should remove pulp tissue and not invade the periodontium. That’s not to say that I am against passing a patency file past the CDJ or even slightly beyond the foramen. However, remember that the area is six times the radius squared. This means that a #15 (0.15 mm) patency file’s tip occupies nearly 5 percent of the average foramen’s cross-sectional area (0.60 mm²) and only 21 percent of the average constriction’s area (0.30 mm²).

I suspect patency files are used more for warning of an impending ledge than for maintaining patency. The downsides are the likelihood of a patency file lacerating vital tissue beyond the constriction and possibly causing postoperative pain in an asymptomatic vital case. A clean cut of the pulp at its narrowest point (apical constriction) is also a biologically acceptable approach. In necrotic cases it would likely push infected material into the periodontium and possibly cause a flare-up.

Termination Point

Where to terminate WL (our clinical target) requires two reference points. The first one is the coronal reference point on the crown, and the second is in the apical part of the canal. The AAE Glossary states that a root end is “a passage or channel in the root of a tooth extending from the pulpal chamber to the apical foramen.”2 Note that the foramen defines the end of the canal. This narrows the choices for WL somewhere between the foramen and the CDJ/constriction.

The Glossary positions the apical constriction “usually 0.5 to 1.0 mm short of the center of the apical foramen,” but positions the CDJ “ranging from 0.5 to 5.0 mm from the anatomic apex.”3 The last word, apex, is very important. If the CDJ can be as much as 5 mm from the apex, it means that the apex is not a precise reference point for WL determination and should not be used. Clearly, apices and foramen can’t be used interchangeably, and evaluating the quality of an obturation by its distance from the apex is wrong.

A meaningful discussion of WL only take place when it is understood to be measured in millimeters from the foramen and not the apex. So, let’s not talk about the apex because it’s irrelevant, and let’s not pretend that the apex is the same as the foramen. It’s all about the foramen, which is usually not at the apex.4,5

Fig. 2a. Photograph showing the foramen, constriction and apex.

Now, let’s change the situation to where WL is perfect, but WL is not (Fig. 2c). There is a dramatic difference between what happens to the bacteria in a canal that is directly cleaned and filled canal (Fig. 2e) versus one where necrotic tissue remains. When this happens, the door is not shut since the root canal sealer cannot replace the infected tissue. Bacteria that are present and produce rapidly. Because the infected pulp is 1 mm from the apex (Fig. 2d), the continuous production of bacteria and their toxins exiting the foramen was too much for the body defenses and the case failed.

Gutierrez and Aguayo4 examined 140 teeth with a scanning electron microscope. They found no foramina located exactly at the apex, and the average distance of the foramen from the apex ranged from 0.2 mm to 3.8 mm. The foramen gives a precise reference point for WL determination — the apex does not.

If we use the foramen, rather than CDJ/constriction or apex, as a firm reference point, we can readily narrow down the best locations for WL. I purposely use the plural to emphasize the two acceptable locations — 0.5 mm from the foramen or 1.0 mm from the foramen. Why not agree on a WL that ranges from 0.5 mm to 1.0 mm short of the foramen? I think that’s reasonable, and here’s why.

Let’s say that I believe WL should be 0.5 mm short of the foramen whereas you think it should be 1.0 mm short of it. Could that say my choice is correct, whereas yours is not and your treatment will fail? Of course not!

Body’s defenses

Let’s say that I will WL further using a photograph of a root end (Fig. 2a) and add an instrumented and obturated canal (Fig. 2b), closing the door and preventing further bacterial contamination. Let’s compare WL that apical to the gutta-percha are cornered with no place to run. They are destroyed by polymorphonuclear leukocytes (PMN), and any remaining debris is cleaned up by the macrophages.

Hypothetically, let’s now miss our WL by 1 mm (short) (Fig. 2c). Just as in Fig. 2b, the door has been shut and the bacteria are trapped. What happens to the bacteria between the foramen and the gutta-percha seal when the WL is perfect or 1 mm short of “length?” The answer, the bacteria are attacked and destroyed by the PMNs — the major circulating defense cells in the immune system, whose function is to kill bacteria. In fact, when the body encounters an infection, the production of PMNs increases ten-fold. Another body defense cell is the macrophage, whose function is to clean up the debris — a task it does very well — as evidenced by the rapid disappearance of extruded root canal sealer.

Now, let’s change the situation to where WL is perfect, but the case failed. The foramen was too small. The case failed.

How to locate WL clinically

Let’s consider that WL should range from 0.5 mm to 1.0 mm from the foramen, how do we find it? I believe electronic apex locators (EALs) have contributed greatly in making WL determination more scientifically based. No longer do we have to engage in the foolishness of evaluating a treatment by the aesthetic proximity of obturating materials to the radiographic apex. It’s worth repeating: the apex has nothing to do with WL — it’s all about the foramen. This, then, begs the question — why are the electronic devices called apex locators?

Apex locator is a poor name, and the manufacturers should call them what they are — foramen (or apical) locators. I recommend we use electronic foramen locator (EFL) and get rid of the term apex locator from here on.

During my teaching years, we evaluated radiographic ‘dead-on’ apices, obturations. I am currently teaching through the constriction to or slightly beyond the foramen and obturating to that point for an aesthetically pleasing X-ray is not scientifically justified.

Knowing the limitations of radiographs for WL determination, let’s see how electronic foramen locators provide greater accuracy. As with all electronic devices, carefully read the instructions. But, if they say that the activation of the ‘hells, lights or whistles’ tells you that you are at the apex, I strongly believe the operator should ask where the tip is — how do we solve this dilemma and make EFLs clinically useful? Unfortunately, during surgical retreatment, the dead-on’s were overfills of most of the time. I had to constantly re- mind students of this fact (and proved it during their training) by re-examining teeth that were through the constriction to or slightly beyond the foramen and obturating to that point for an aesthetically pleasing X-ray is not scientifically justified.

Fig. 2b. A ‘perfect’ obturation ‘closing the door’ against further bacterial contamination from apical bacteria apical to the gutta-percha are trapped and destroyed.

Fig. 2c. WL short of the desired location (constriction), but the WL is correct and the door is closed.

Fig. 2d. Distal canal of mandibular molar cross-sectioned 1 mm from apex. WL was correct but was not because the Biodentine file size was too small. The case failed.

Fig. 2e. Example of ‘shutting the door’ obturation. Compare with Fig. 2d.

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we have to do what the manufacturers should have done. If the alarms indicate the tip is at the apex, but we think it’s at the foramen we should subtract 0.5 mm to 1.0 mm from the file insertion length to get WL. If the alarm is indicating apex but we believe the tip is actually at the constriction, then we should use that for WL. And finally, if the manual says that the bents, lights or whistles go off at the constriction, you will have to confirm the accuracy of that statement. You may have to do some fine tuning as you gain practical clinical experience with specific devices. A little practice and careful observations while using your EFL will be required.

The good news is that in spite of their shortcomings, EFLs provide consistently better accuracy than X-rays. They also should help resist the temptation of indulging in ‘aesthetodontic’ contests. In our lectures and writings we could show X-rays of cases that appear ‘short’ but are not without worrying about our work being judged inferior. All we would have to do is advise the audience beforehand that all WL were 0.5 mm to 1.0 mm from the end of the canal using the accuracy of an electronic foramen locator rather than the inaccuracy of an X-ray.

Alternative technique for WL determination

I give credit for this technique to Bill Wildey, the co-inventor of Light-Speed™. Bill uses Light-Speed™ instruments (Discus Dental Inc., Culver City, Calif.) to fine-tune WL. He starts with the estimated length given by the EFL; he then goes 1-2 mm beyond that length with the LSX rotating in the handpiece. The short blade of the LSX #20 (Fig. 3a) usually passes easily through the constriction, because the estimated diameter of the constriction is roughly #50. Depending on the actual diameter of the constriction (if one exists), the LSX #25 or #50 usually engages the walls of the constriction and a ‘popping’ sensation is felt when the blade goes through the constriction. This tactile feedback gives the exact location of the constriction and the desired location of WL. The key is to advance the instruments very slowly to feel what’s happening in the canal. If a constriction is not present, the popping sensation will be felt passing through the foramen.

Larger LSX sizes, if advanced slowly (recommended technique) to the same WL, will allow for the development of an apical stop matrix. Once developed, the LSX should have to be pushed hard to force it past the stop. Of course, demolishing the constriction where the stop is located (the WL) is not recommended. The apical stop confines our fills to the WL and helps minimise the incidence of over-fills.

Notice the length marking rings on the shank of the LSX (Figs. 3b, 3c). I can assure you that significant time savings (and greater accuracy) is possible if you use the rings in lieu of rubber endo stops. In fact, Bill Wildey recommends you have your assistant remove the stops before bringing them chairside to force yourself to make the transition.

Conclusion

In our subconscious minds, we are aware there is a biologic tolerance to WL. Cases obturated a little short (or a little long), are usually successful when everything else is done correctly. WL need not be perfect for a successful outcome (biologic tolerance), but the tolerance for an inaccurate WW is not so generous. Avoid the temptation of indulging in ‘aesthetodontic’ contests. The endodontic community should agree to a WL that ranges 0.5 mm to 1.0 mm from the foramen (not apex) and move on to more important issues.

I recommend all manufacturers use the term electronic foramen locator (EFL) rather than apex locator to describe these devices. EFL manufacturers should eliminate ambiguous markings on their devices and simply pinpoint only the foramen. Dentists would then ‘do the math’, thereby choosing a termination point that is either 0.5 mm or 1.0 mm short of that location. And finally, emphasis should be placed on clean-up of the main canal as well as possible correct WW) close to the constriction/CDJ. Doing so closes the door, prevents bacteri-a/toxins from contaminating apical tissues and increases the chances of endodontic success.

Smart Endodontics™ offers many helpful tips. To learn more, please call Discus Dental at (800) 817-3636. Request the free CD showing what Smart Endodontics is all about.

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References


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