

Endodontic success and working length: thinking three-dimensionally

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In the article "Endodontic success: it's all about the apical third" (Roots magazine, Vol. 4, Issue 1, 2008, pages 14–19), we introduced the term working width (WW). Don't be surprised if you have never heard this term – it's quite new and warrants a brief description. WW is the canal's pre-instrumented diameter, adjacent and coronal to the apical constriction (Fig. 1). I like this term very much, because it is a valuable reminder that canals are three-dimensional. 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

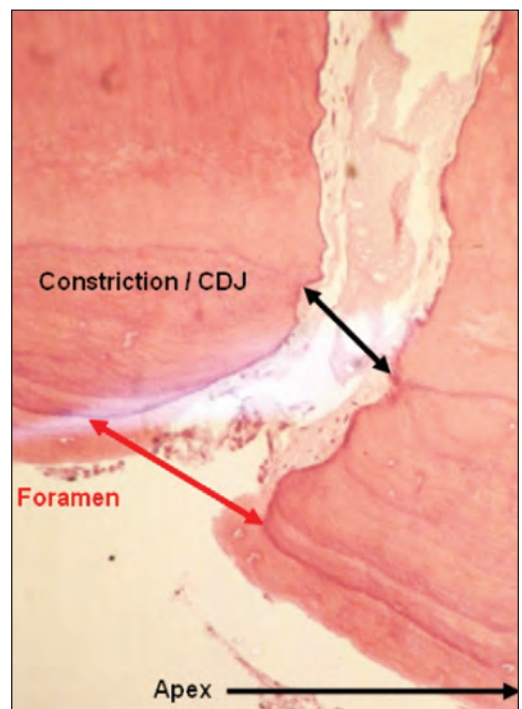
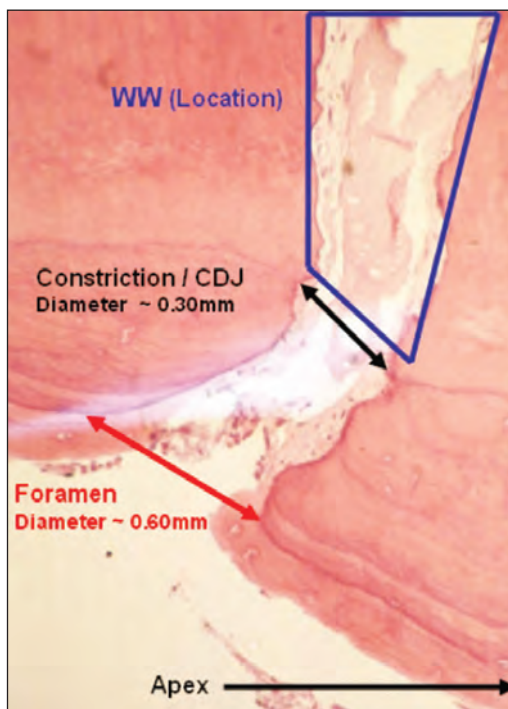
There is considerable disagreement regarding ex-

actly where working length (WL) should terminate. Let's explore the reasons and try to make sense 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 cementodentinal junction (CDJ) (Fig. 1), which is approximately co-located with the apical constriction. Most agree with that

Fig. 1 Root-end anatomy. Working Width (WW), outlined in blue, is the canal width coronal to the constriction. If the average size of a constriction is #30, a larger instrument is required to clean this area. Note that the CDJ (black arrows) is co-located with the constriction.

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



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'm against passing a patency file past the CDJ or even slightly beyond the foramen. However, remember the formula, $Area = \pi \times r^2$. This means that a #15 (0.15 mm) patency file's tip occupies only 5 percent of the average foramen's cross-sectional area (0.60 mm) and only 25 percent of the average constriction's area (0.30 mm)!²

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 a more biologically acceptable approach. In necrotic cases it would likely push infected material into the periapical tissue 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 canal is: "a passage or channel in the root of a tooth extending from the pulp chamber to the apical foramen."¹ Note that the foramen defines the end of the canal. This narrows the choices for WL to 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 3.0 mm from the anatomic apex."¹ The last word, apex, is very important. If the CDJ can be as much as 3 mm from the apex, it means that the apex is not a precise reference point for WL determination and should not be used. Clearly, apex 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 can 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.^{2,3} Gutierrez and Aguayo³ 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 really 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 I say that my choice is correct, whereas yours is not and your

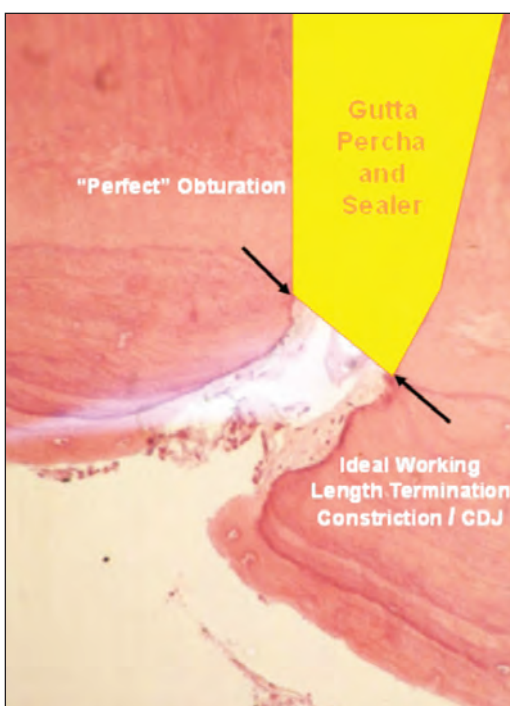


Fig. 2b A "perfect" obturation "closing the door" against further contamination from above; bacteria apical to the gutta-percha are trapped and destroyed.

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

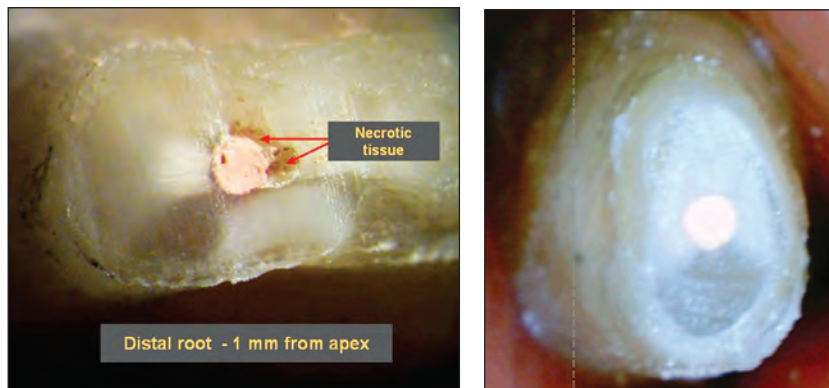


Fig. 2d Distal canal of mandibular molar cross-sectioned 1 mm from apex. WL was correct, but WW was not because the final instrument size was too small. The case failed.

Fig. 2e Example of a “closing the door” obturation. Compare with Figure 2d.

treatment will fail? Of course not!

The body's defenses

Let's discuss 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 from above. Bacteria 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 Figure 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 that length? Same answer, the bacteria are attacked and destroyed by the PMN — the major circulating cell in the immune system, whose function is to kill bacteria. (In fact, when the body encounters infection, the production of PMN increases tenfold.) Another body defense cell is the macrophage, whose function is to clean up the debris⁴ — 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 WW is not (Fig. 2d). There is a dramatic difference between what happens to the bacteria in a correctly 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 feast on the tissue and reproduce 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.

There seems to be a widespread belief that the immune system behaves differently at the apex compared to other places in the body. The apex is not a mystery zone — the defense mechanisms there are “alive and well” and fully functional. The misunderstanding, I think, arises from the errant belief that canals in necrotic cases lack a blood supply. This is true — high up in the canal — but not within the

region associated with WL. This part of the canal is in close proximity to a generous blood supply.

How to locate WL clinically

Now that we have decided that WL should range from 0.5 mm to 1.00 mm from the foramen, how do we find it? I believe electronic apex locators (EAL) 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 constriction) 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 the apex” obturations. When the teeth were extracted or viewed during surgical retreatment, the dead-on's were overfills most of the time. I had to constantly remind students of this fact (and proved it during their training with extracted teeth). Blasting 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 “bells, lights or whistles” tells you the file tip is at the apex, isn't that a problem? Since the apex is not the end of the canal, exactly where is the tip? How do we solve this dilemma and make EFLs clinically useful? Unfortunately, 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 bells, 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 your specific device. 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



Fig. 3a LightSpeedLSX™ NiTi rotary instruments with a very short blade and non-cutting shaft.

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 1.00 mm from the end of the canal using the accuracy of an electronic foramen locator rather than the inaccuracy of an X-ray.

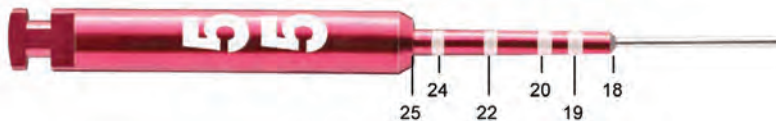


Fig. 3b Length-marking rings on the shank can be used as an alternative to rubber endo stops (25 mm LSX).

Alternative technique for WL determination

I give credit for this technique to Bill Wildey, the co-inventor of LightSpeed™ (Fig. 3a). Wildey uses LightSpeedLSX™ instruments (Discus Dental, 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 small size of the LSX #20 blade usually passes easily through the constriction

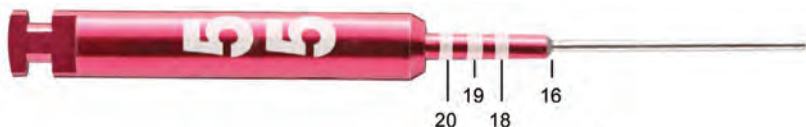


Fig. 3c Length-marking rings on 21 mm LSX.

because the average diameter of the constriction is roughly #30. Depending on the actual diameter of the constriction (if one exists), the LSX #25 or #30 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 would 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 minimize the incidence of overfills.

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, 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 1.00 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 cleaning the main canal as well as possible (correct WW) close to the constriction/CDJ. Doing so closes the door, prevents bacteria/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.

I wish to thank Steven S. Senia, BSIE, MBA, for his valuable contribution to this article.

References

1. Glossary of Endodontic Terms. American Association of Endodontists 2003, 7th Ed. Chicago, IL.
2. Yury Kuttler. Microscopic investigation of root apexes. JADA 1955; 50: 544–52.
3. Juan H, Gutierrez G, and Patricia Aguayo. Apical foraminal openings in human teeth. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 1995; 79: 769–77.
4. Mandell et al. Principles and Practice of Infectious Diseases. Churchill Livingstone, 5th Ed, 2000.

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