**Endodontic success and working length: thinking 5-dimensionally**

By E. Steve Senia, DDS, MS, BS

I n the article Endodontic suc- cess: it's all about the apex (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, even in the dental literature. WL is the canal’s preinstru- mented diameter, adjacent and coronal to the apical constric- tion (Fig. 1), like this term very much, because it is a valuable reminder that we have to think dimensionally. Instrumentation should address a working length and a working width. My last article fo- cused on working width, this article fo- cuses on working length.

**Definition of working length**

There is considerable dis- agreement regarding exactly where working length (WL) should terminate. Let’s explore the reasons for this and the sense of it all. The American Associa- tion 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 be termi- nate.” 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 (CEJ) (Fig. 1), which is approximately colocated with the apical constriction. Most agree with this location, because the pulp makes dentin and the periodontium makes cementum. Instrumentation should re- move pulp tissue and not invade the periodontium. That’s not to say that I am against passing a patency file past the CEJ or even slightly bey- ond the foramen. However, re- moving the file past the area 5 to 10 times the radius squared. This means that a #15 (0.15 mm) pa- tency file’s tip occupies nearly 5 per- cent of the average foramen’s cross-sectional area (0.060 mm) and only 2.5 percent of the average con- striction’s area (0.050 mm)!

I suspect patency files are used more for warning of an impending ledge than for maintaining pa- tency. The ledges are the like- lihood of a patency file lacerating vital tissue beyond the constrictic- tion and possibly causing postop- erative pain in an asymptomatic vital case. A clean cut of the pulp at its narrowest point (apical con- striction) is an aesthetically accept- able approach. In necrotic cases it would likely push infected material into the dentinal tubules and possibly cause a ‘flare-up.’

**Termination Point**

Where to terminate WL (our clinical target) requires two refer- ence 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 constriction is: “a passage or channel in the root of a tooth extending from the pulp chamber to the apical foramen.” Note that the foramen de- fines 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 5.0 mm from the anatomic apex.’ The last word, apex, is very impor- tant. If the CDJ can be as much as 5 mm from the apex, it means that the apex is not a precise refer- ence point for WL determination and should not be used. Clearly, apex and foramen cannot be used interchangeably, and evaluating the quality of an obturation by its distance from the apex is wrong.

A meaningful discussion of WL only takes place when it is understood to be measured in millimeters from the foramen and not the apex. So, let’s talk about the apex because it’s irrelevant, and let’s not pretend that the apex is the same as the fora- men. It’s all about the foramen, which is usually not at the apex.²,³

Gutierrez and Aguayo¹ 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 pre- cise reference point for WL de- termination — the apex does not.

If we use the foramen, rather than CDJ/constriction or apex, as a firm reference point, we can re- ally narrow down the best loca- tions for WL. I purposefully use the plural to emphasize the two ac- ceptable 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? 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 isn’t and your treatment will fail? Of course not!

**Body’s defenses**

Let’s think about WL further us- ing a photograph of a root end (Fig. 2a) and add an instru- mented and obturated canal (Fig. 2b), closing the door and pre- venting further bacterial con- tamination from above. Bacteria trapped in the gutta-percha are corners with no place to run. They are destroyed by polymor- phonuclear 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). As 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 ‘apical length’? Same answer, the bacteria are attacked and de- stroyed by the PMN — the major circulatory defense cell in the immune system, whose function is to kill bacteria. (In fact, when the body encounters infection, the produc- tion of PMN increases ten- fold.) Another body defense cell is the macrophage, whose func- tion is to clean up the debris — a task it does very well — as evi- denced by the rapid disappear- ance of extruded root canal seal.

**How to locate WL clinically**

Let’s say that I believe 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 con- tributed greatly in making WL deter- mination more scientifically based. No longer do we have to engage in the foolishness of eval- uating a treatment by the aes- thetic 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 angulation) locators. I recommend use electronic foramen locator (EFL) and get rid of the term apex locator from here on.

During my teaching years, we evaluated radiographs: ‘dead-on’ obturation, obturation past the foramen. We didn’t locate the tip. Today, with the teeth were extracted or viewed during surgical retreatment, the ‘dead-on’ were overfilled most of the time. I had to constantly re- mind students of this fact (and proved it during their training). Now, students can, when choosing through the construction 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 ra- diographs 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 tip is at the apex, isn’t that inadequate? Because 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 finetuning as you gain practical clinical experience with your own 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 inducing 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 to 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 Willey, 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. 5a) usually passes easily through the constriction, because the 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 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 over-fills.

Notice the length marking rings on the shank of the LSX (Figs. 5b, 5c). 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 Willey 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 the foramen. Dentists would then ‘decide’ whether 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


About the author

Dr. E. Steve Senia earned a DDS degree from Marquette University in 1963. He entered the Air Force (previously served as a pilot) and completed a GPR residency. In 1969, he received a MS and Certificate in Endodontics from The Ohio State University. He served in the Air Force and retired in 1981 as a Colonel, Chairman of Endodontics at Lackland AFB, Texas. He then became Professor and Director of the Endodontic Postdoctoral Program at the University of Texas Dental School at San Antonio. He retired in 1992. Dr. Senia is a Diplomate of the American Board of Endodontics. He is a former member of the Editorial Board and the Scientific Advisory Panel of the Journal of Endodontics, an editorial advisor for the Journal of Endodontic Practice and a consultant for the NASA Space Program. He has lectured and published extensively and is the co-inventor of the Light-Speed™ root canal instrumentation and SimpliFill® obturation systems. You may contact Dr. Senia at DrSteveSenia@aol.com.