Tapered Shaping Objectives Can Make Your Life Easier!

by L. Stephen Buchanan, DDS, FICD, FACD

You can generally divide endodontists into 2 groups: the traditionalist group who abhor any amount of surplus filling material beyond the internal aspect of root canals (most endodontic educators), and the warm gutta-percha group who actually prefer to see a sealer puff beyond each of the canal's portals of exit and who are okay (although not pleased) with surplus gutta-percha at the end of the canal.[1] The traditionalists usually quote the numerous published research papers showing a higher incidence of failure associated with overfills while the "gutta-percha warmers" claim that they have never seen a root canal fail due to surplus material.

Endodontists are all fairly bright people, so what explains this hotly argued disparity in opinion? It's obscure but very simple — it's all about shaping objectives and techniques.

Etiologies for Failure

Fifty-seven out of 63 research studies[2] on this topic concluded that overfills are an etiology for endodontic treatment failure. But again, this does not square with decades of clinical experience and literally millions of root canal procedures done in that time by clinicians who prefer a reasonable amount of surplus to any under-filled canal space. If we think about it a bit, it does seem odd that despite research findings that gutta-percha and most sealers are relatively biocompatible,[3-5] we blame these materials for inciting persistent inflammation and infection.[6] Did we miss the turn, with our eyes riveted on the obvious and embarrassing evidence of our less-than-perfect control of the case — the overfill — because we have no way to clinically assess the cause of the crash? Did we mistake coincidence for etiology?

One of dentistry's premier leaders on microbiology in endodontics, Dr. Sjögren[7] brought the controversy closer to a realistic clinical answer to the question of etiology with his classic study that clearly correlated the presence of infection with the outcome of the therapy. He showed that fewer endodontic treatments were successful when periapical pathosis was seen preoperatively (86%), than when there were no periapical lesions seen preoperatively (96%). Furthermore, he showed that the apical level of root filling had no significant influence on the outcome of treatment when previously root-filled teeth with periapical lesions were retreated.

So it's not the surplus filling material that causes failure, it's the bacteria. This should not be a surprise, since we know that dental decay and pulp death only occurs in the presence of bacteria.[8] So far, so good. But now consider Sjögren's other important finding: the apparent disconnect between the apical extent of obturation and success. The conclusion drawn from that finding was that it doesn't improve clinical outcomes to fill the entire root canal system.

There lies the real watershed — the continental divide — in our specialty. Because of Sjögren's paper and his observation that the apical extent of obturation is not a predictor of success in the retreatment of infected root canals (as evidenced by the periapical lesion), the majority of clinicians at that time were convinced that it didn't matter if you treated root canal systems to their full apical and lateral extents. And, as a result, single cone and cold lateral condensation obturation were viewed to be as effective as any of the methods that were more 3-dimensional, specifically those involving condensing heat-softened gutta-percha. So we are back at the same conundrum — why do some endodontists feel most insecure about our chances of success when we have filled less than the full length of the primary canal, nevermind those lateral spaces?

Albert Einstein once said that the important thing was to ask the right questions. The right question, in my opinion, is why do overfills occur in the first place? Most dentists misunderstand how this happens, thinking that they overextended the fill because they fit the cone wrong or pushed too hard on the condensation device. Yet again, most of us have missed the turn. The correct answer is simple but obscure.

Consider the fact that the prevalent root canal preparation taught through the years of modern endodontics (1950 to the present) has been the apical stop technique. An apical stop is basically an intentional ledge that is cut just short of the end of the canal (Figure 1) to prevent the obturating material from exiting into the periapical tissues. Conceptually this makes sense, as it is nearly impossible to fill beyond a ledge in a root canal if it is mistakenly cut short of the terminal region of the canal.

But what happens if there has been an error in length determination or the canal length has shortened during shaping procedures due to its curves and the files used (Figure 2)? Instead of ending up with definitive resistance form cut at the intended position short of the canal terminus, the preparation has been extended to or beyond the end of the root canal. As the stop prep has little taper in the apical 3 mm, there is now very little, if any, resistance form remaining in the preparation — and this is in a relatively straight canal — what happens in canals with apical curvature?

With the relatively large apical preparation sizes recommended in this technique — a No. 35 file size, minimum, in small canals — and the stiffness of the stainless steel files used for these preparations through most of our history, apical transportation and ripping has been a common result in apically curved canals.[8]

Unfortunately, these 2 untoward outcomes, loss of resistance form due to erroneous length determination and apical laceration due to shaping file aggression, leave very few clinical clues prior to obturation, especially if the apical prep is done early in the procedure. Cone fitting can seem to be excellent despite poor results during the preparation of the apical third, especially if the canal is dried before conefit.

In this case, the cone is fit in an environment of artificially created friction between the gutta-percha and the dry canal wall. When the cone is buttered with sealer — which acts like a lubricant — it then sails out the end of the canal (Figure 3), engendering mystery and dismay on the part of the clinician.

Tapered Shaping Objective

Now let's look at the outcome of a preparation cut with a tapered shaping objective in mind. While the

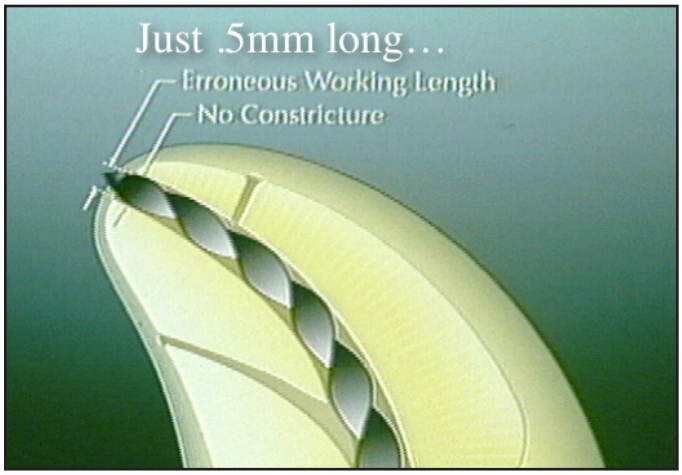

Figure 2. K-file overextended due to erroneous working length determination, or shortening of a curved canal during shaping procedures. As a result, there is little or no resistance form in the preparation.

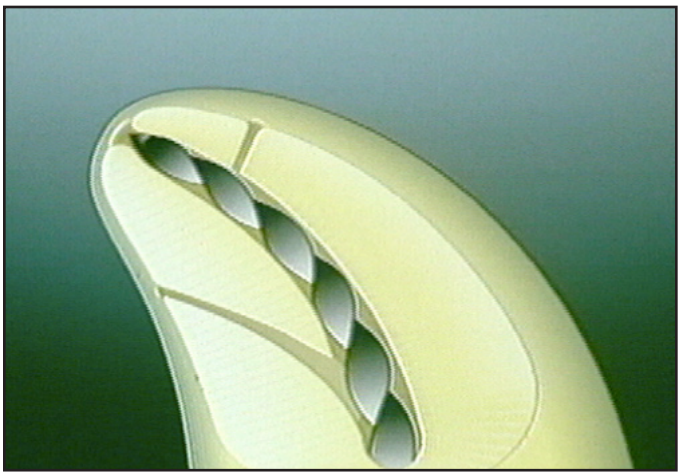

Figure 1. Apical stop preparation cut into the canal ½ to 1 mm short of the terminus of the root canal.

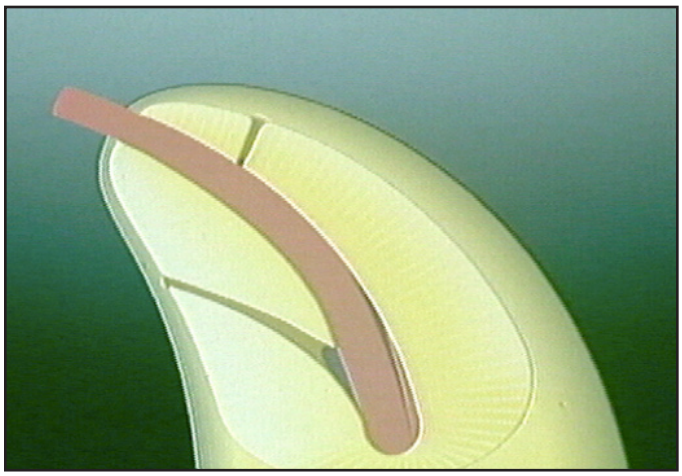

Figure 3. Because of the lack of resistance form, and the lubricious nature of the sealer beside the gutta percha cone, it sails out the end of the root canal with very little apical pressure—usually just the use of a lateral condensation spreader.

Apical Stop delivers what I call "point resistance form" — meaning that it is all present at a single point in the canal — tapered shaping results in what I call "linear resistance form," meaning that it exists along several millimeters of apical canal length.

The greatest advantage of linear resistance form and the tapered shaping objective is that it is forgiving of length determination errors. If you use landed-blade shaping instruments (ProFile [ProFile GT], and GTX [DENTSPLY Tulsa], K3 [SybronEndo]), you can accidently cut these rotary files beyond the canal's terminal length without deleterious results; you just end up with a larger apical diameter than you expected during shaping (Figure 4). Of course this does not hold true for nonlanded rotary files taken past the terminus in curved apical canal regions — significant apical ripping can happen in a second (Figures 5 and 6).

If a canal has been cut erroneously long with an apical stop preparation, the clinician, if lucky enough to realize the error before obturation is completed, must redetermine length, cut the apical prep to at least 2 sizes larger than before, refit the cone, take a new conefit x-ray image, and finally complete the case. Canals that have been cut erroneously long with a tapered shaping objective only require that the dentist cut the cone back to the correct length and fill the canal (Figures 7a, 7b) — 15 minutes versus 20 seconds.

It must be said that even tapered root canal preparations can be done with less-than-ideal obturation results, if the tapered preparation ends short of the terminus of the canal. The result in that case is better than that of a poorly done stop preparation; however, the apical extent of the true seal in a tapered root canal prep is limited to the apical extent of the taper. In an inadequately done tapered prep, the most apical extent of the seal will be limited to the coronal extent of apical parallelism. Only by using apical gauging procedures to confirm the apical continuity of the tapered preparation can the seal be predictably accomplished to the full length of the root canal.

Many clinicians who have recently begun using aggressively-fluted rotary files have wondered why apical accuracy of obturation has flown out the window — usually thinking that something has gone wrong with cone fitting or condensation efforts. Again, it is all about resistance form — in this case,

Figure 5. CT reconstruction of relative fidelity of landed vs non-landed shaping files in apically curved canals. Note the significant transportation with the non-landed instruments.

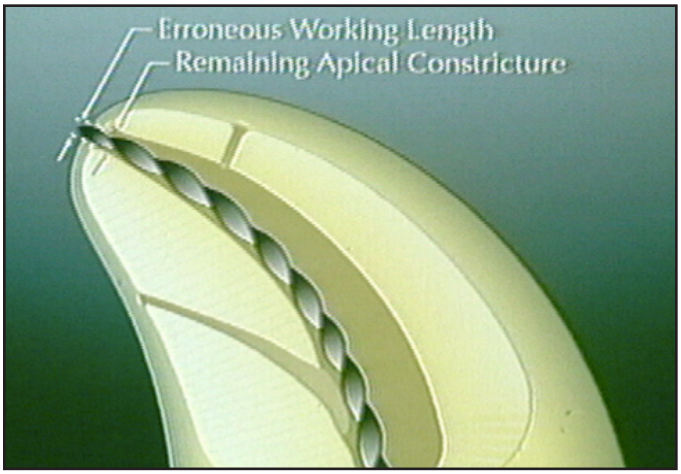

Figure 4. Tapered shaping file over-extended due to erroneous length determination. As a result the apical diameter of the canal will be larger than the tip of the file, however, if the shaping file has radial lands the resistance form in the preparation remains.

Figure 6. Non-landed shaping file overextended due to shortening of a curved canal during preparation. Notice the elipticized, ripped terminal morphology—difficult or more likely impossible to adequately seal during Obturation procedures.

apical transportation has lessened or eliminated the apical taper needed to retain the filling material in the canal terminus. Even with tapered shaping objectives, overfilling will be seen when gauging errors occur, although without apical transportation there will be little chance of failure to seal the canal.

Mistaking Coincidence for Etiology

What does this have to do with overfills, failures, and the controversies that swirl around these issues? It explains how most of those studies mistook coincidence for etiology and how we are often fooled in the deconstruction of our filling failures. Overfills are coincidental to failures, and the quality of obturation is not directly related to the apical extent of the fill.

A sterilized root canal doesnít need to be perfectly obturated, or perhaps not bturated at all, for healing to be achieved. No bacteria, no periradicular endodontic pathosis. Unfortunately, we can do our best to disinfect the root canal space in all of its complexity, using the most effective irrigating solutions and the latest irrigation delivery technology, but we can never say thatwe have sterilized it. We only use the word "disinfect" in endodontics, never the word "sterilize," because — at least with the tools we have at this point in time — we can't do it.

So how do we achieve predictable success in spite of our clinical shortcomings on the cleaning side? By wearing "belts and braces" (suspenders), as the English would say it. By cleaning the best we can, but also by obturating the best we can. Again, if all of the bacteria in a root canal system are killed due to our thorough irrigation efforts, we can achieve success in spite of a mediocre seal of that space. Conversely, we can be successful when we have not killed all of the bacteria in a canal if we seal them inside the canal during our obturation procedures. That is the point that Sjögren missed in his paper's conclusions — because he did not evaluate the quality of the shaping results, he really had no clue about the quality of obturation, regardless of the apical extent of filling and as such, had no basis to say that it did not matter how completely the root canal is filled.

For those of us who strive to cut ideal apical preparations and seal the full apical and lateral extents of root canal systems, filling short has been the most commonly observed clinical state related to failed treatment in our hands aswell as in the hands of others.

The primary point of this article is to point out that the quality of obturation matters to our success or failure — way more than whether there is surplus filling material at the end of treatment — and the quality of our obturation procedures is primarily dependent on our shaping outcomes.

Complexity of Procedure

None of the foregoing is to say that ideal clinical results cannot be accomplished when using the apical stop prep. I am just saying that tapered shaping is more predictable in the hands of a wide range of clinicians' talent and experience. Beyond the more consistent shaping results provided with a tapered

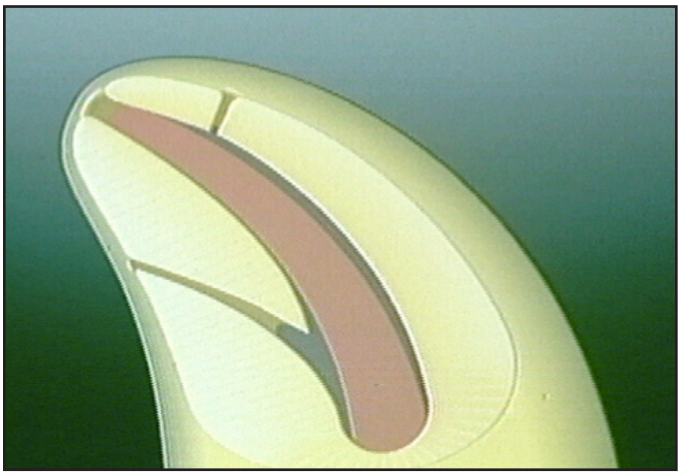

Figure 7a. The gutta percha cone has been cut to the appropriate shorter length, is buttered with sealer, and is placed in the canal. Recovery time is just 20-30 seconds after discovery of the mistaken length determination.

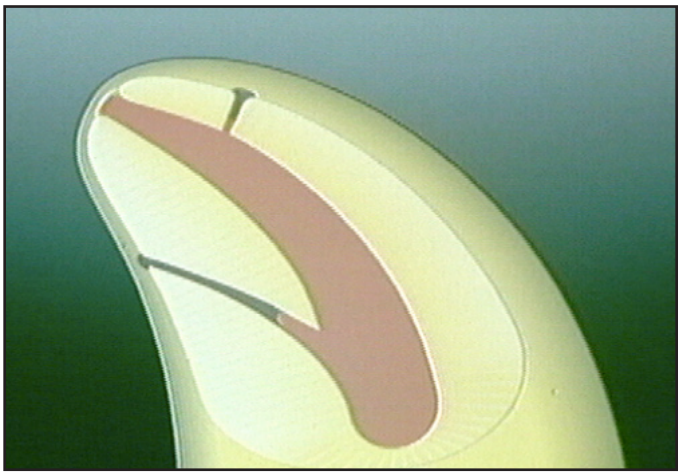

Figure 7b. The condensed gutta percha does not move beyond the canal terminus because adequate resistance form is maintained, despite the length determination error.

shaping objective is the greater efficiency that is possible compared with the apical stop prep.

The apical stop prep typically requires 6 to 10 instruments, depending on what type of instruments are used to accomplish the shaping objective. After initial negotiation to a No. 15 k-file, Nos. 20, 25, 30, and 35 file sizes are required to cut an apical stop in a small canal, after which you retreat back 3 mm, flare the more coronal portion of the canal by serially stepping back with 3 to 5 larger instruments, and finish the preparation with one to 2 Gates-Glidden drills used in the coronal third.

Tapered shaping preparations with state-of-the-art rotary files require just one to 3 instruments to complete, maybe 4 in an especially challenging anatomy (Figure 8). So, this shaping objective requires a very small inventory of instruments to address 95% of the root canals you will meet in practice (Figure 9). The exception is the relatively rare canal with large apical diameters, where bringing in the standard Accessory GT Files will manage the shaping need.[9] The number of sizes of gutta-percha points and paper points needed with this preparation objective is also remarkably small.

How Much Taper Do We Need?

In 1986, when I first proposed that we should have variably-tapered shaping files, my intention was to more simply replicate the shapes we had created with serial-step-back shaping. When I reverse-engineered my cases by measuring the amounts of taper I created with k-files and Gates Glidden burs, I found that they ranged from .04-.12 mm/mm. GT Files, first introduced in 1991, had tapers of .04, .06, .08, .10, and .12 in order to replicate those shapes.

One of the seminal realizations that came from that research was the understanding that we were not creating tapering shapes that were consistent throughout the length of the canal; actually, the tapers we created with serial step-back instrumentation were much greater in the apical third and much less in the coronal third. This suggested the unique GT File feature of designated maximum flute diameters (MFD), so that the coronal shape in a preparation could be controlled and limited to a safe, conservative dimension: 1mm in small canals, 1.25 mm in medium sized canals, and 1.5mm in large canals.

Since then it has become apparent that less apical taper is necessary to accomplish predictable resistance form, due to the very precise shaping results possible with radial-landed rotary files, thus the smaller range of tapers required to finish a case with the GT*X* system — just .06 and .08 — both of which have a 1 mm MFD. While these more conservative coronal shaping objectives may seem inadequate or less sexy to clinicians who were originally trained

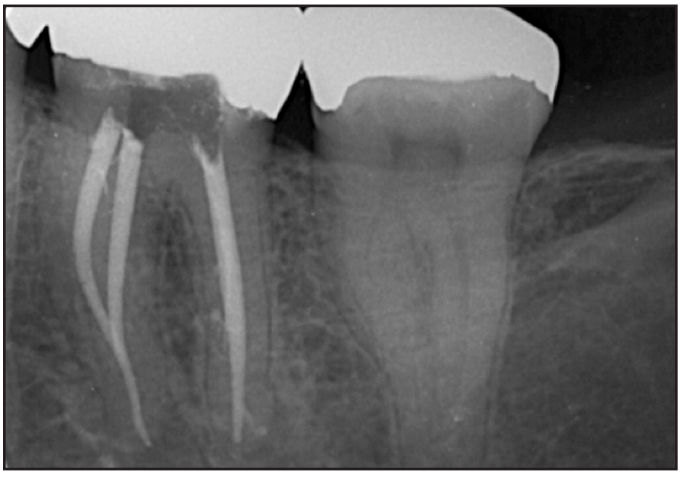

Figure 8. Radiograph showing mandibular molar shaped with 1-2 GT*X* Files per canal. The narrow mesial canals with multi-planar curvatures required a 20-.04 and a 20-.06 for completion of the needed shapes. The distal canal was ideally shaped with just one GT*X* File—a 30-.08. Note the fidelity to the original canal path—all of the original curves in the mesial canals have been followed rather than straightened—testament to the predictability of radial-landed shaping files.

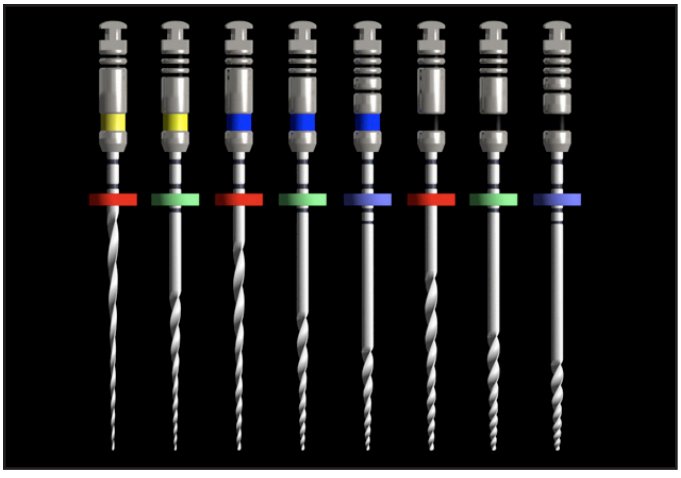

Figure 9. The GT*X* family of shaping instruments. Just 8 instruments that will address 95% of all canal anatomy.

to cut bigger preps, those larger coronal shapes are in truth an irrational holdover from the days of more rigid files and condensation devices. If you remain in the large coronal shaping camp, just ask any prosthodontist who does expensive full-mouth remodels for their patients whether he or she wants more or less structural integrity in the natural tooth abutments that have had endodontic treatment. You will hear unanimous support for smaller coronal shapes.

There is only one reason I can think of to cut large coronal shapes and that is because limiting coronal enlargement to a 1mm diameter will make it difficult to do cold lateral condensation obturation, as there is little room beside the master cone for a spreader and multiple accessory cones to be placed. So think about this irony — do you really want to reduce the structural integrity of the root by over-enlarging the coronal third of the canal so you can wedge (yet again increasing the chance of root fracture) a lateral condensation spreader in there to do a filling method not much better than single cone filling?

As an aside, the root canal shapes cut by instruments with a MFD limitation will have a bit of coronal parallelism in roots of larger apical diameters and long length, so standardized tapered gutta-percha points will prematurely bind at the orifice level before binding at the end of the prep. Gutta-percha points that fit these shapes (the shank ends are limited to a .9 mm diameter) are made by DENTSPLY/Tulsa under the brands GT and GT*X*, and by SybronEndo in both gutta-percha as well as Real Seal (Resilon) to fit these shapes under the Autofit brand.

How Much Apical Enlargement Do We Need?

Another hotly argued issue in the treatment of root canal pathoses is how large should we cut apical preparations. Some endodontic educators recommend enlarging the end of root canal preparations to at least a size No. 40 file with the thought that the average terminal diameter of small canals has been shown to be around 0.33mm. I take issue with this for several reasons.

1. Averages have no place in treatment. It is my opinion that we need to measure, or gauge, the terminal diameter of root canals and then cut a preparation that is appropriate for that specific canal. Having a fixed preparation size for all small canals results in gross over-enlargement of most canals and leaves some apically resorbed canals undertreated.

2. The larger the file size taken to the end of the preparation, the greater the chance there is of transporting or ripping delicate apical canal regions. Transportation is a function of 2 variables (assuming the canal is curved) — stiffness of the file and sharpness of the flute edges. Larger files, even when they are made out of nickel titanium, are much more rigid than small files and when large enough, even radial landed files will transport curved apical regions of canals.

3. It is a pipe dream that severely-curved canals can be enlarged much beyond their original diameters without great risk of apical damage and file breakage.

4. Dentin can be cleaned without being overcut if effective irrigating solutions and methods are used. I would not say that one is wrong to want to cut dentin all the way to the end of the preparation, although I believe it to be unnecessary in virgin canals if irrigation has been adequately accomplished. For those who irrigate for limited lengths of time and do single visit treatment, larger apical preparations are advised. In those cases, be very careful to use safe instruments (radial-landed with radiused file tips) and a tapered shaping objective.

How Can Tapered Shaping Objectives Improve your Life Doing Root Canal Treatment?

Why should you think hard enough to understand and use[9-12] "taper-centric" shaping and filling procedures? If you can bend your mind around the concepts and methods needed to create tapered apical resistance form, you will gain these advantages:

•Total forgiveness of length determination errors when using shaping files with safe tip and flute geometry.

•Fewer files and fewer procedural steps needed to complete ideal shapes.

•Fewer gutta-percha and paper points needed to fit a variety of prepared canals.

•More consistent apical accuracy of obturation.

Endo is plagued by the difficulty we have in deconstructing our failures because everything is so small and hidden from direct view. Because of this, very few dentists understand that overfills are only associated with failure of treatment when apical damage has been caused during shaping procedures and the main etiological factor (infection) was not properly addressed. While I agree that apical extrusion of filling material should not be our clinical objective, when tapered shaping is well done and the canal has been sealed to its full apical and lateral extents, surplus filling material — while perhaps regretted for esthetic reasons — will not lower the prognosis of treatment (Figures 10a and 10b).

Acknowledgement
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Figure 10a. Radiograph of a maxillary central incisor showing a very large apical lesion with surplus gutta percha and sealer.

Figure 10b. The 6 month recall showing ideal healing, despite overfill. This treatment was successful because of the perfect tapered shape that was cut to the terminus of the canal which led to an ideal seal (courtesy of Dr. Arnaldo Castellucci).

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