recorded working length. The radiographic assessment is only capable of determining the relationship of the master cone to the radiographic apex and not to the anatomical apical foramen or constriction. However, this method of radiographic assessment is widely used in clinical studies in the literature as a method of determining satisfactory root canal treatment.^{1–3,26}

If the outcome measure is deemed acceptable, this does not necessarily mean that the root canal filling is actually within the root canal system, because the anatomical foramen may be 2 or 3 mm away from the radiographic apex. This problem may affect the PA group more than the AL group. On the other hand, when using the apex locator, a root canal filling may appear to be short on a radiograph (more that 2 mm) but in fact it is at or close to the apical foramen. The available assessment technique does not allow the operator to assess if the root filling is confined to the root canal system. Cone beam CT may provide a new standard for assessment of root canal success, however the high radiographic dose, low resolution and expense may hinder its use.32

In this study, the apex locator was only used once to measure root canal length. This single use method was used to simulate the most common practice by general dental practitioners. However, this can lead to inaccuracies due to changes in length of the canals after preparation, especially in curved roots. In addition, other factors such as the presence of vital tissue, irrigants in the canals, metal restorations or caries can lead to inaccurate readings.¹⁰ Therefore, a more reliable method to confirm the working length may be to utilise the apex locators throughout the root canal treatment.

Although using the apex locator to determine the working length gave a higher proportion of acceptable GP master cones, this pilot study was not powered to detect a statistically significant difference between the two groups.

CONCLUSIONS

In general dental practice, no significant difference was observed in working lengths when determined using an apex locator combined with a master cone GP radiograph or using the conventional method. There is a need for further studies to assess the effectiveness of different methods of working length determination and their effect on the clinical outcome of root canal treated teeth in general dental practice.

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- Sjogren U, Hagglund B, Sundqvist G, Wing K. Factors affecting the long-term results of endodontic treatment. J Endod 1990; 16: 498–504.
- Farzaneh M, Abitbol S, Lawrence H P, Friedman S. Treatment outcome in endodontics – the Toronto Study. Phase II: initial treatment. *J Endod* 2004; 30: 302–309.
- Schaeffer M A, White R R, Walton R E. Determining the optimal obturation length: a meta-analysis of literature. J Endod 2005; 31: 271–274.
- 4. Kuttler Y. Microscopic investigation of root apexes. *J Am Dent Assoc* 1955; **50:** 544–552.
- Dummer P M, McGinn J H, Rees D G. The position and topography of the apical canal constriction and apical foramen. *Int Endod J* 1984; 17: 192–198.
- Simon S, Machtou P, Adams N, Tomson P, Lumley P. Apical limit and working length in endodontics. Dent Update 2006; 36: 146–153.
- Olson A K Goerig A C, Cavataio R E, Luciano J. The ability of the radiograph to determine the location of the apical foramen. *Int Endod J* 1991; 24: 28–35.
- Tamse A, Kaffe I, Fishel D. Zygomatic arch interference with correct radiographic diagnosis in maxillary molar endodontics. Oral Surg Oral Med Oral Pathol 1980; 50: 563–566.
- Sunada I. New method for measuring the length of the root canal. J Dent Res 1962; 41: 375–387.
- Gordon M P, Chandler N P. Electronic apex locators. Int Endod J 2004: 37: 425–437.
- Kim E, Lee S J. Electronic apex locator. Dent Clin N Am 2004; 48: 35–54.
- ElAyouti A, Dima E, Ohmer J, Sperl K, Von Ohle C, Löst C. Consistency of apex locator function: a clinical study. J Endod 2009; 35: 179–181.
- Pagavino G, Pace R, Baccetti T. A SEM study of in vivo accuracy of the Root ZX electronic apex locator. J Endod 1998; 24: 438–441.
- Hoer D, Attin T. The accuracy of electronic working length determination. *Int Endod J* 2004; 37: 125–131.
- Tselnik M, Baumgartner J C, Marshall J G. An evaluation of Root ZX and Elements diagnostic apex locators. *J Endod* 2005; **31:** 507–509.
- Haffner C, Folwaczny M, Galler K, Hickel R. Accuracy of electronic apex locators in comparison to actual length – an *in vivo* study. *J Dent* 2005; 33: 619–625.

- Goldberg F, Marroquin B B, Frajlich S, Dreyer C. *In vitro* evaluation of the ability of three apex locators to determine the working length during retreatment. *J Endod* 2005; **31**: 676–678.
 Dental Practice Board. *DPB digest of statistics*.
- Eastbourne, UK: Dental Practice Board, 2004. 19. Molyneux L. Mccullough C. Preston A J. Jarad F
- Molyneux L, Mccullough C, Preston A J, Jarad F D. Apex locator use by general dental practitioners in Merseyside. J Dent Res 2008; 87(Spec Iss C): Abstract number 0166 (PEF IADR). Available from: http://iadr.confex.com/iadr/pef08/techprogram/ abstract_111422.htm.
- Faculty of General Dental Practice (UK) of the Royal College of Surgeon of England. *Selection criteria for dental radiography*. London: FGDP(UK), 2004.
- European Society of Endodontology. Quality guidelines for endodontic treatment: consensus report of the European Society of Endodontology. *Int Endod J* 2006; 39: 921–930.
- Saad A Y, al-Nazhan S. Radiation dose reduction during endodontic therapy: a new technique combining an apex locator (Root ZX) and a digital imaging system (RadioVisioGraphy). J Endod 2000; 26: 144–147.
- Brunton P A, Abdeen D, MacFarlane T V. The effect of an apex locator on exposure to radiation during endodontic therapy. J Endod 2002; 28: 524–526.
- American Association of Endodontists. AAE endodontic case difficulty assessment form and guidelines. Endodontics: Colleagues for Excellence 2005; Spring/Summer: 6–7. Available from: http:// www.aae.org/uploadedFiles/Publications_and_ Research/Endodontics_Colleagues_for_Excellence_ Newsletter/ss05ecfe.pdf.
- Williams C B, Joyce A P, Roberts S. A comparison between *in vivo* radiographic working length determination and measurement after extraction. *J Endod* 2006; **32:** 624–627.
- Ng Y L, Mann V, Rahbaran S, Lewsey J, Gulabivala K. Outcome of primary root canal treatment: systematic review of the literature – part 2. Influence of clinical factors. *Int J Endod* 2008; 41: 6–31.
- Smadi L. Comparison between two methods of working length determination and its effect on radiographic extent of root canal filling; a clinical study. BMC Oral Health 2006; 6: 4.
- Kim E, Marmo M, Lee C-Y, Oh N-S, Kim I-K. An *in vivo* comparison of working length determination by only Root-ZX apex locator *versus* combining Root-ZX apex locator with radiographs using a new impression technique. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2008; **105**: e79–e83.
- D'Assunção F L, Albuquerque D S, Salazar-Silva J R, Dos Santos V C, Sousa J C. *Ex vivo* evaluation of the accuracy and coefficient of repeatability of three electronic apex locators using a simple mounting model: a preliminary report. *Int Endod J* 2010; 43: 269–274.
- Wrbas K T, Ziegler A A, Altenburger M J, Schirrmeister J F. *In vivo* comparison of working length determination with two electronic apex locators. *Int Endod J* 2006; 40: 133–138.
- Stoll R, Urban-Klein B, Roggendorf M J, Jablonski-Momeni A, Strauch K, Frankenberger R. Effectiveness of four electronic apex locators to determine distance from the apical foramen. Int Endod J 2010; 43: 808–817.
- Patel S, Kanagasingam S, Mannocci F. Cone beam computed tomography (CBCT) in endodontics. *Dent Update* 2010; **37:** 373–379.

Corrigendum

General article (*BDJ* 2011; 211: 379-385):

'See you in three months! The rationale for the three monthly periodontal recall interval: a risk based approach' In the above general article, the caption for Figure 3 should have read: BOP is 9%, six residual pockets \geq 5 mm, four teeth had been lost, the bone factor in relation to the age is 0.75 and there are genetic influences.