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The role for 'reminders' in dental traumatology: 2. The effectiveness of a reminder stamp compared with the current clinical practice for documenting the diagnostic working length

Day PF, Duggal, MS. The role for 'reminders' in dental traumatology: 2. The effectiveness of a reminder stamp compared with the current clinical practice for documenting the diagnostic working length. © Blackwell Munksgaard, 2006.

Abstract – The aim of this study was to establish if a predesigned prompt in the form of a reminder stamp placed in a patient's dental records is more effective for recording the essential details of a diagnostic working length compared to the current practice without any specific prompts. Following a pilot study of current practice, a stamp was introduced. Twelve months following the introduction of the stamp, 198 patient records were examined, where endodontic treatment had been carried out mainly for traumatic injuries. The following parameters were specifically investigated whether a radiograph had been taken to establish working length and was it available for examination, whether the working length was recorded in the notes and whether a reference point for the measurements was given. The working length was conventionally recorded by 127 notes, whereas 71 used the stamp. A working length radiograph was taken and a working length recorded for 95% of the cases where no stamp had been used, compared to 100% of the stamp group. Where no stamp had been used only 83% of working length radiographs were available compared to 100% of the stamp group. Interestingly, a reference point from where the working length had been measured was only recorded in 5% of the cases where the stamp had not been used compared to 94% using the predesigned stamp. This result was statistically significant using a chi-squared test ($P < 0.001$). The stamp was generally more effective than the conventional method of recording the working length for endodontics.

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Key words: dental trauma; audit; record keeping; reminders; prompts; working length estimation; endodontics; paediatrics; immature non-vital permanent incisors

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Literature review

The estimation of the working length is of utmost importance in root canal treatment for non-vital traumatized permanent teeth. It is measured from a reference point on the tooth's cavosurface, that is, within the clinician's field of view to a point at or close to the apex of the tooth.

During the development of the immature root, the apical foramen of the tooth is located at the apex

of the tooth. It is relatively easy in such cases to define the working length on radiographs because first, the two points coincide at the end point of the root and the apex is visible radiographically and second, in an immature root there is no apical constriction. With a mature tooth there is no longer a single histologically evident point where the root ends. There are three different points (1): the root apex, the apical foramen and the apical constriction. The root apex is the most apical point on the root and is visible radiographically. The apical foramen is the junction between the internal aspect of the root canal and the external surface. It is marked by a change from dentine to periodontal ligament and cementum. This point is used by electronic apex locators, as there is a difference in impedance between the two mineralized surfaces. The apical constriction is the narrowest point of the root canal. A considerable variation in position has been reported for these three points for maxillary and mandibular incisor teeth (1). Permanent incisor teeth are further complicated in their estimation of working length by not always having their major foramina of root canals located at the root apex (2) and in a small number of teeth there having accessory foramina in the apical region (2). Despite these complications, it is generally believed that in a mature root canal, the optimal point for the apical limit of root canal preparation is the apical constriction (3).

Where the estimated working length is inaccurate, a number of significant problems can result. If the working length estimation is short, the major foramina and any accessory canal will not undergo either chemical disinfection or mechanical instrumentation. This leaves several millimetres of untreated canal system, thereby increasing the risk of endodontic failure. Where the estimated working length is short of the apical constriction, there is a risk that this error may be continued through to obturation. The long-term success of the root canal treatment has frequently been linked to the apical limit of obturation (4–6). Where obturation was greater than 2 mm short of the radiographic apex, the success rate dropped from 94% to 68% at 8–10 years (5). In addition, for immature teeth underestimation of the working length can lead to further complications where apexification is attempted. These include a hard tissue barrier forming short of the apex and or the down growth of granulation tissue into the root canal.

An overestimation of the working length can also lead to the problems. When the obturation was beyond the root apex for a non-vital tooth, success rates dropped to 76% at 8–10 years (5). The decreased success rate was postulated to be related to the extrusion of canal bacteria and infected dentine into the periapical tissue and external surface of the root canal. Second, complication of an incorrect working length is the overinstrumentation of the apex with a resulting increase in the diameter of the root foramen. This can increase treatment time for immature teeth undergoing apexification (7) and risk extrusion of intracanal medicaments into the periapical tissues and consequent pain and discomfort (7, 8).

It can be seen that an inaccurate estimation of the working length can significantly reduce the chances of success of endodontic treatment. Various methods have been advocated for the determination of the working length. Both conventional and digital radiography are still the most widely used methods in the UK. Though the radiographic technique is reported to be only accurate in 60–80% (9, 10) of the cases for mature teeth, a working length X-ray is still considered the 'gold standard' (3, 11, 12).

Other methods, such as electronic apex locator, can also be used and have been shown to have a similar accuracy on their own to the working length X-rays in a mature permanent root (9). Consequently, a combination of radiographs and electronic apex locators is recommended (13). In immature teeth, however, considerable inaccuracies have been reported with apex locators (14, 15). A further technique for immature teeth has been described by Baggett et al. (16). The technique involved a size 30 paper point which was 'gently pressed along the canal with light finger pressure until, if no anaesthesia was used, the child reported they could feel it, and/or the rebound of the paper point was observed by the operator'. Using two experienced clinicians, there was 0.81 and 0.88 accuracy with the gold standard of the working length X-ray. In 95% of cases, the disagreements were less than 1 mm in comparison to the radiographic working length. Although this paper reported the apparent success of the technique in a subsequent paper on apexification by the authors (17), the use of a working length X-ray was still advocated.

It is clear therefore, that the radiographs are still the mainstay for the estimation of working length in endodontics. However, it is important to record this accurately using a stable reference point. The accurate recording in patients' records is important, especially in teaching institutions where patients might be seen over multiple visits by different operators. The aim of our study was therefore, to investigate whether a prompt or a 'reminder' in the patients clinical records was effective in improving the recording of essential details required for the accurate estimation of a working length compared with the current practice without any specific prompts.

Materials and methods

Identification of dental records where root canal treatment had been carried out for traumatized teeth

Patients who had undergone root canal treatment for traumatized teeth were identified by going through the notes of all patients who had attended the Trauma Clinic at Leeds Dental Institute between January 2000 and January 2002. The current practice, which did not involve any specific prompts, was evaluated according to the six criteria detailed later. In January 2002, a prompt for the recording of working length in the form of a stamp was introduced (Fig. 1). Once the working length stamp (WLS) was introduced, all the patients' record numbers (file number) where the stamp had been used were recorded.

The scoring criteria used for the recording of important details expected for working length estimation

Based on a review of the literature, a gold standard that should be expected to be recorded for the working length was established and all patient records were evaluated for these six criteria both before and after the introduction of the stamp. These criteria were:

1. *Was a diagnostic radiograph taken?* For a yes to be recorded in the data collection, a radiograph must be present with a file *in situ*. This is consistent with the current guidelines available for endodontics (3, 11, 12).
2. *Was the radiograph available for examination?* For a yes to be recorded in the data collection, the radiograph had to be available to the author to examine. It had to be present either in the patients' notes or as in the case of digital radiographs on the clinic computer, which is located in the Paediatric Dentistry Department, Leeds Dental Institute.
3. *Was the diagnostic working length recorded in the notes?* For a yes to be recorded in the data collection, working length estimation must be recorded in millimetres. In some situations, the working length estimation was not the same as the working length of the X-ray taken, e.g. the file was short or long with regard to the apex. Where this happened should be detailed and the estimation of the corrected working length recorded.
4. *Was a reference point identified?* For a yes to be recorded in the data collection, the working length estimation must detail what part of the crown was used as the reference point from which the working length estimation was made.
5. *Was the reference point 'stable'?* For a yes to be recorded in the data collection, a stable reference point must be used for working length estimation. Due to the risk of further trauma to the crown of the traumatized tooth (18), a stable reference point was a reference point taken from an adjacent undamaged tooth.
6. *Were the recordings legible in the notes?* For a yes to be recorded in the data collection, the clinical records must be legible.

Each identified clinical record was examined to see if these six criteria had been recorded. Where there was a positive recording of that criterion, this was recorded in the data collection sheet as 'yes'. If no recording could be found it was recorded as 'no'. A set of clinical notes detailing all six factors would receive six yes's in the data collection sheet.

A published paper using a similar stamp to the one developed in this study was found in the orthopaedics literature (19), where the use of the stamp gave a 30% improvement for recording the operational steps involved. These data were used as a basis for a power calculation for our study. For a power calculation with an α value of 5% and a β value of 90%, we would require a minimum of 25 patients in each group. Because of the variability of these results and the uncertainty of applying these figures to dento-alveolar trauma, we elected to use as many clinical records we could find. We examined 127 clinical records before the stamp was introduced and 71 after the introduction of the stamp.

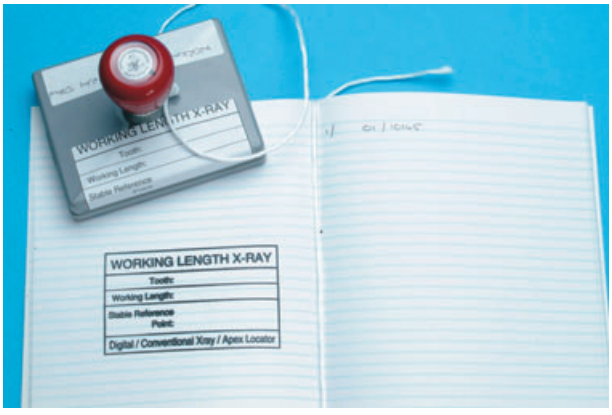

Fig. 1. The Working Length Stamp

Data analysis

The data were entered onto SPSS 10.1[1]. Chi-squared and Fisher's exact statistical tests were used to study differences between the two groups and a Mann–Whitney test was used where the data were non-parametric.

Results

Table 1 shows that the WLS improved the recording of most parameters for working length estimation. For the recording of a stable reference point and legible recordings in the notes, however, WLS made no difference. For five cases in the no stamp group (NSG), no radiograph for working length estimation was taken.

Table 2 shows that there was no significant difference in the NSG or WLS groups for the number of visits for root canal treatment prior to a working length X-ray being taken.

Table 3 shows that there was better retrieval of radiographs using digital technology rather than conventional methods at the time of carrying out the study. This difference was highly significant ($P < 0.001$).

Table 2. The mean, standard deviation and minimum and maximum number of visits of root canal treatment prior to a working length X-ray being taken and the definitive working length being established

Method of recording working length	Number of patients' records	Mean number of visits (±SD)	Minimum	Maximum
No stamp	127	2.2 ± 1.1	1	7
Stamp	71	2.4±1.6	1	10

Using a Mann–Whitney test for non-parametric data, there was no significant difference between the two groups.

Table 3. Influence of the method of taking the radiograph on whether the X-ray was available for examination

		Was X-ray available for examination	
How was X-ray taken	Total	Yes	No
Digital	57	57	0
Conventional	141	119	22
Total	198	159	22

Using Fisher's exact test, there was a highly significant difference ($P < 0.001$) between the methods of storing the radiograph.

Discussion

The WLS was aimed at reminding the clinician to record the information they already know. If a working length radiograph is taken without details of the length and reference point, it is of little value. The importance of preventing a repeat X-ray is due to the small risk of biological damage if repeated despite dental radiology employing a low dose of ionizing radiation (20). This risk is known as the 'stochastic effect'. The stochastic effect is random and there is no minimum dose. Therefore, with every dental radiograph, there is the possibility of inducing a stochastic effect. Examples of diseases that have been attributed to stochastic effects radiograph include leukaemia and certain types of tumour. The severity of the damage to the cell is not related to the size of the inducing dose. The estimated risk of a fatal cancer developing from an intra-oral dental exposure is 0.2 per million, e.g. one tumour for every five million exposures. In children, however, the risk of exposure is increased by a factor of three (21) due to their high cell replication rate and their long life expectancy. Therefore, all methods of dose reduction and limitation (22) should be carried out and this includes improving the clinical recording of the working length. It is clinically unacceptable for a radiograph for working length estimation because of poor clinical record keeping to be repeated.

The literature review has shown that a radiographic estimation of working length is still the gold standard, especially in immature teeth. It is interesting to note that in the NSG, no working length X-ray was taken in about 5% of the cases and, therefore no radiographic working length was recorded. However, when a radiograph had been taken for the purposes of recording the working length, it was recorded in the patients' records in all cases both for the NSG and for the WLS. These figures are considerably better than those reported by Schockledge et al. (23).

The WLS significantly improved the recording of a reference point from which the radiographic estimation of working length was taken. With endodontics for immature teeth taking several visits and often seen by different operators, what one clinician may see as an obvious reference point may not be obvious to another and therefore the original

Table 1. Clinical parameters that were recorded when the radiographic working length was established both before and after the introduction of the stamp

Clinical parameter	No stamp (%) ($n = 127$)	Stamp (%) ($n = 71$)	Fisher exact test (one sided)	Chi-squared test
Was a working length radiograph taken?	121 (95)	71 (100)	$P = 0.07$	
Was the radiograph available for examination?	105 (83)	71 (100)		$P < 0.001$
Was the radiographic working length recorded in the notes?	121 (95)	71 (100)	$P = 0.07$	
Was a reference point identified?	6 (5)	67 (94)		$P < 0.001$
Was this 'stable'?	0 (0)	0 (0)		
Were the recordings legible in the notes?	127 (100)	71 (100)		

clinician should record it in the patients' records. It is worth discussing whether a stable reference point is an appropriate clinical parameter. The reason why we chose to use an adjacent undamaged tooth as a stable reference point was due to the work by Robertson et al. (18), where it was shown that there was a short life expectancy of composite crown buildups for traumatized teeth (2–4 years) and an additional 10% risk of further trauma to the tooth itself. There are, however, considerable problems with using an adjacent undamaged tooth, including the potential differential eruption of adjacent teeth and the physical difficulty of taking the measurement and recording it.

The WLS did not improve clinical practice or handwriting. There was a 100% legibility of handwriting in both the groups. In the NSG group, however, over a minute was often taken trawling through the clinical records trying to find where the working length was written. In the WLS group, it rarely took more than 10 s because the imprint of the stamp was easy to find in the records. This is an additional benefit for clinicians.

There was little difference between the groups with the number of visits that patients attended for root canal treatment before a working length estimation was carried out (Table 2). There is a difference in treatment philosophy between immature and mature root canal treatments. For the immature tooth, the working length should be established as early as possible to prevent the complications described in the literature review. In a mature tooth, the coronal preparation and disinfection is important, as this area is the most highly infected (3). In addition, the complications described for immature teeth are less likely and a more significant risk of failure is the extrusion of infected material through the apex (5, 6). As this study was on a childhood population, the establishment of a working length within the first two visits would be expected. Unfortunately, in neither group did this occur. Some of the possible reasons why the radiographic working length was not taken within the first two visits may be patient cooperation or the considerable time it takes for patients to go to the radiology department for the radiograph to be carried out coupled with waiting for the X-ray to be processed; a scenario which takes at least 10 min. The introduction of the digital radiology for working length estimations occurred during the study period. This equipment is able to process the X-ray within seconds and is located on the children's clinic, which obviates the need to walk to the radiology department. Despite these benefits, there was no improvement in the number of visits before the working length was established between the conventional and digital X-ray groups.

The method of taking the radiograph influenced significantly whether the X-ray was available for examination at the time of the audit (Table 3). Where the radiograph was taken by conventional means and stored in the patients' records, 84% of radiographs were available compared to 100% for the digital X-ray. Although the digital radiographs were more accessible to examination, images stored digitally on a computer are liable to the same problems as any other computer. Conventional radiographic images in this study were more likely to go missing or be lost. The conventional radiograph group compared less favourably with the figures of previously reported studies (23) where 90% of the X-rays were available for examination.

Conclusions

- A reminder in the form of a WLS significantly improved the recording of working length estimation in clinical records.
- Radiographic images for the estimation of working length are easier to access if stored on computer than by conventional means.

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