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Root canal treatment in mandibular canines with two roots: a review of the literature and a report of three cases

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ABSTRACT

Endodontic treatment may sometimes fail because the morphological features of the tooth can adversely affect the treatment procedures. Mandibular canines can present with complex internal anatomy and many investigators have reported associated anatomical variations.

This paper describes three clinical case reports of mandibular canines, each with two roots and two canals. In addition, the prevalence, aetiology, root morphology and the clinical and radiographic diagnoses for mandibular canines that present with this anatomical variation will be discussed.

INTRODUCTION

Root canal treatment on a tooth is performed with the intention of eliminating any infection and preventing the possibility of re-infection in the root canal system.[1]

The configuration of the root canals of any tooth can be complex and when treatment fails to locate, clean, shape and obturate them effectively, complications can arise. These include post-operative pain and disease in the affected tooth and surrounding structures.[1-3]

Numerous factors can contribute to the failure of endodontic treatment and may include persistent infection in the root canal (which was not eliminated at the initial treatment phase), inadequate approach to cleaning and shaping (leading to poor root canal preparation), broken instruments and incomplete obturation of the prepared root canal.[4]

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It is evident that a thorough knowledge of root canal anatomy is needed as well as the anticipation of possible variations associated with each tooth are vital to ensure a more predictable prognosis with the completed treatment.[5]

The canine is considered to be the "cornerstone" of the dentition and plays a vital role in mastication because of its morphology and its location in the oral cavity.[6]

Practitioners should take into consideration that although the mandibular canine usually has one root with a single root canal[6-8] the possibility exists that there may be more than one canal. However, the anatomy of the root canals does not necessarily correlate with the shape of the tooth.

In other words, a treating clinician must be careful not to always assume a standard presentation with one root and one canal, as the mandibular canines can display different anatomical variations.[9] An early study by Nair et al. concluded that root canal morphology plays a crucial role in endodontic treatment and could greatly influence successful outcomes.[10]

A great number of clinicians have the conception that a given tooth will inevitably contain a precise and regular number of root canals and roots. Unfortunately, careful consideration of the available literature reveals that variations of tooth morphology are indeed common, and this includes the mandibular canine.[4,7,11-14]

PREVALENCE OF ROOT CANALS IN MANDIBULAR CANINES

The mandibular canine is generally considered a tooth with mono-radicular morphology and a single root canal.[6-8] This is not always the case. The reported incidence of two root canals in a mandibular canine with one root varies between 1% and 15%,[7,8,11-13] with minor differences in findings between authors.

A further variation includes the mandibular canine with two roots and two root canals, having an incidence of up to 12.08%.[8,15-17]Another rare configuration was reported by Heling and co-workers, who treated a mandibular canine with two roots and three canals.[14]

AETIOLOGY OF MANDIBULAR CANINES WITH TWO ROOTS/TWO CANALS

An investigation of the literature revealed that the incidence of mandibular canines with two canals and/or two roots might be higher in certain populations and races than in others.[6,15-17]

Studies conducted by means of diverse methodologies have focused on different populations and races in different parts of the world. A review of the literature available at the time (1963) summarised the results of various studies determining the presence of a second root in mandibular canines in a variety of populations (Table 1, below).[16]

More recent literature has revealed similar results. An incidence of 1.7% of mandibular canine teeth with a second root was found in a Brazilian survey of 830 mandibular canines (Table 1).[15] A recent study of an Iranian population discovered a relatively high number of two-rooted mandibular canines (18 out of 149 teeth), the highest incidence recorded (See Table 1).[17]

The studies conclude that different genetic models exist among different races and populations, which influence the morphological appearance of all teeth.[18-21] According to the findings of the studies, it can be speculated that different genetic models can invoke a higher incidence of two or more canals and/or roots in mandibular canines.

EXTERNAL ROOT MORPHOLOGY

The root morphology of the mandibular canine is very similar to that of other teeth, but larger. The root is wider in diameter from buccal to lingual compared with mesial to distal dimension.

Developmental depressions can be observed on the mesial and distal surfaces of the root.[22] According to various authors these depressions can be deep and may create the appearance of a bifurcated root or a second root.[23-27]

An actual bifurcation may occur at the cervical, middle, or apical third, of the root surface.[28] Sharma et al. (1998) concluded that the most common area of bifurcation occurred at the apical third (56.9%), followed by the middle third (40%), and finally the apical third (3.1%).[29]

This anatomical aberration can be bilateral according to certain studies and case reports.[30,31] Sharma and co-workers also measured the average lengths of the buccal and lingual roots of 65 mandibular canines with two roots. It was found that the average length of the buccal roots was 23.0 mm and of the lingual roots, 22.7 mm.

In 47.7% of the teeth investigated, the buccal roots were longer than the lingual root and 43.1% of teeth possessed buccal and lingual roots of equal length.[29] Taylor[28] analysed the size ratio between the labial and lingual roots of 179 mandibular canines with an additional root.

Three variations could be observed in the investigation; these were: (1) 65.3% with proportional buccal and lingual roots; (2) 27.4% with a greater diameter of the labial root compared with the lingual root; and (3) 7.3% with the lingual root displaying a greater diameter than that of the buccal root.[28]

RADIOGRAPHIC DIAGNOSIS

Intraoral radiographs have traditionally been seen as invaluable in assessing the internal anatomy of teeth. In cases where multiple canals or additional roots are suspected, radiographs taken from different angles can increase the diagnosis of hidden anatomy and potential challenges.[32]

Radiographic images should be carefully studied and analysed in an effort to detect any detail suggesting root morphology with bifurcations or trifurcations. An apparent sudden discontinuity of a root canal pathway might also indicate hidden anatomy.[33]

The use of periapical radiographs has certain disadvantages, which include superimposition of anatomical structures and a limited two-dimensional image. These factors reduce the diagnostic potential of the radiographs in cases of unusual anatomy.[34,35]

In recent years, Cone Beam Computed Tomography (CBCT) imaging has become a standard tool in the field of endodontics for identifying suspected variations in tooth form, curvatures, and bifurcations.[35] CBCT imaging offers the benefit of three-dimensional views as compared with the traditional two-dimensional periapical radiographs.

Table 1: Studies reporting the prevalence of lower canine teeth with two roots in different population groups.

Author	Ethnic Group	Number of lower canine teeth	Number of lower canine teeth with two roots	
Hillebrand (1909)	Hungarians	1707	103	(6%)
Schwerz (1916)	German	507	31	(6.1%)
Fabian (1928)	German	315	20	(6.4%)
Hjelmman (1929)	Finnish	98	5	(4.9%)
Shaw (1931)	South Africans	62	1	(1.6%)
Visser (1948)	Dutch	2488	123	(4.9%)
Pedersen (1949)	Inuit (Greenland)	72	1	(1.3%)
Huche (1954)	French	282	28	(10%)
Pécora et al. (1993)	Brazilian	830	14	(1.7%)
Rahimi et al. (2013)	Iranian	149	18	(12.1%)

Areas of interest can be viewed on three different planes, and the combination of sagittal, coronal and axial views eliminates the interference of superimposition of anatomical structures that can obscure hidden anatomy, including additional root canals or roots.[22] Assessment of a CBCT also offers the potential to determine tooth lengths in axial and sagittal planes more accurately than is possible on standard radiographs.[35]

CLINICAL DIAGNOSIS

The clinical diagnosis and location of additional canals or roots can be a challenge for clinicians who are urged to approach each endodontic treatment of a mandibular canine (even if it appears to be single rooted) with the mind-set that two canals are present until proven otherwise![36]

The use of magnification can also be beneficial during treatment. Magnification loupes or the Dental Operating Microscope (DOM) have the potential to assist the operator in the location of additional canals.[37] Yousef and Abdullah concluded in a very recent case report that in the re-treatment of a left mandibular canine with two roots, the DOM played an indispensable role in the location of a missed root canal system.[38]

Magnification should form part of an integrated approach in conjunction with sharp endodontic explorers to reveal hidden orifices and altered access preparations to improve vision.[39] The treatment of diverse anatomy in mandibular canines can also be a challenge to the clinician.

The long axis of the buccal canal passes through the surface of the crown very close to the incisal edge or on the labial surface. In an effort to locate the lingual canal orifice, a small pre-curved hand file should be used after initial scouting with sharp endodontic explorers.[9]

Case Report 1

A 55-year-old male patient presented with irreversible pulpitis on his mandibular right canine. A periapical radiograph revealed evidence of a two-rooted canine (Figure 1a). After preparation of a conventional access cavity it was possible to locate only the buccal root canal system (Figure 1b).

A limited field-of-view CBCT scan was taken to help with location of the lingual root canal system. Figure 1c shows a coronal view of the CBCT scan and clearly illustrates the two roots and two root canals of the canine, bifurcating in the middle of the root.

After several attempts to locate the lingual root canal system, it was realized that the access cavity had to be lengthened extensively towards the lingual and gingival aspect of the tooth in order to facilitate the search (Figure 2a).

A periapical radiograph was used to confirm working lengths in the buccal and lingual root canals (Figure 2b, below). After glide path preparation with a ProGlider (Dentsply Sirona) the canals were prepared to full working length using the X1 and X2 ProTaper Next instruments (Dentsply Sirona).

The prepared canals were irrigated with 17% EDTA and heated 3.5% sodium hypochlorite before they were obturated with the use of two X2 ProTaper Next Gutta Percha Points (Dentsply Sirona) in combination with Pulp Canal Sealer (Kerr) and the Calamus Dual Obturation Unit (Dentsply Sirona). Figure 2c (below) depicts the post-operative result after canal obturation.

Case Report 2

The patient, a 51-year-old male, presented with a non-vital mandibular right canine. A pre-operative periapical radiograph revealed a large root canal system in the coronal aspect of the tooth before the canal bifurcated (Figure 3a, p510).

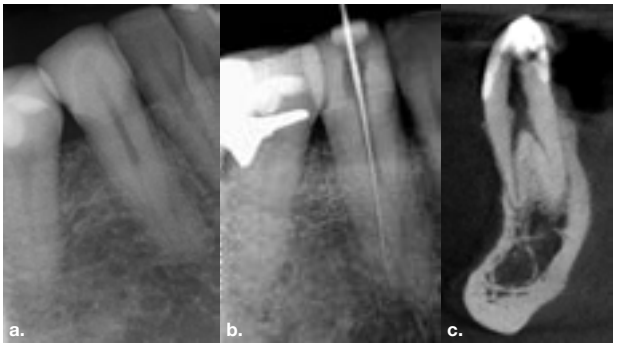

Figure 1. (a) A periapical radiograph of a mandibular right canine; (b) after extending the access cavity it was possible to locate only the buccal root canal system; (c) coronal view of the CBCT scan clearly illustrating the two roots and two root canals of the canine bifurcating in the middle of the root.

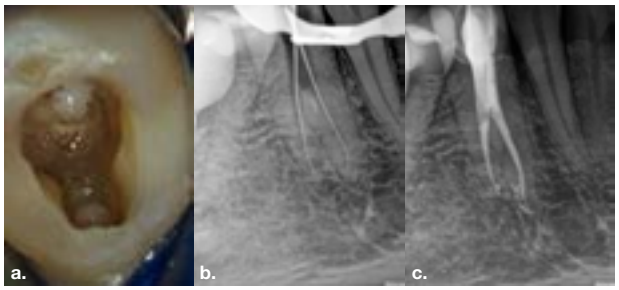

Figure 2. (a) Access cavity outline extended towards the lingual and gingival aspect of the tooth; (b) periapical radiograph to confirm working length in the buccal and lingual root canals; (c) post-operative result after canal obturation.

A limited field-of-view CBCT scan confirmed that there were two separate roots with two root canals bifurcating just below the middle of the tooth (Figure 3b, p510).

After examination of the scan, an access cavity was prepared on the labial aspect of the tooth to provide straight-line access into the two root canal systems.

After glide path preparation the canals were prepared with the Primary 25/07 WaveOne Gold file. After irrigation, two Primary WaveOne Gold Gutta-Percha Points were fitted (Figure 4a, p510) and verified radiographically.

Figure 4b (p510) shows the final result after root canal obturation and the access cavity having been closed with SDR, posterior bulk fill flowable base (Dentsply Sirona) and capped with a final layer of Ceram.x SphereTEC one composite resin (Dentsply Sirona). A coronal slice of a four-month follow-up CBCT scan showed good healing of the periapical pathology (Figure 4c, p510).

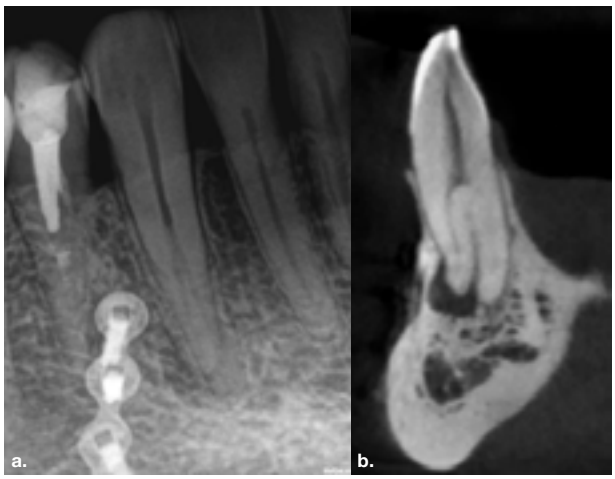

Figure 3. (a) A pre-operative periapical radiograph. Note the canal bifurcation in the midroot area of the canine; (b) coronal slice of a preoperative CBCT scan showing the canine with two roots, two root canals and a large periapical area around the apex of the buccal root.

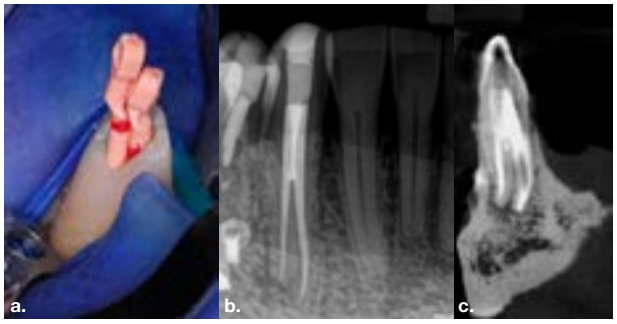

Figure 4. (a) Two Primary WaveOne Gold Gutta-Percha Points fitted through the labial access cavity after root canal preparation; (b) final result after root canal obturation and the access cavity closed with SDR and capped with a final layer of Ceram.x SphereTEC one composite resin; (c) coronal slice of a four-month follow-up CBCT scan showing good healing of the periapical pathology.

Case Report 3

The patient, a 47-year-old female, presented with non-vital mandibular right lateral incisor and canine teeth (Figure 5, below). A preoperative limited field-of-view CBCT scan revealed that the canine had two roots and two canals bifurcating in the apical third of the tooth. The lingual canal bifurcated at an approximate 60-degree angle from the main central root canal system.

Owing to the complex appearance of the root canal anatomy of this tooth the anatomy was explored further in 3D Endo Software (Dentsply Sirona). The software allows the clinician to perform pre-endodontic treatment planning of simple and complex endodontic cases, using DICOM (Digital Imaging and Communications in Medicine) data from a CBCT scan. The benefit and value of this software have been illustrated in previous publications.[40,41]

The 3D planning of the case was done following five easy steps detailed in the software program.

Figure 5. Preoperative periapical radiograph of mandibular right lateral incisor and canine.

In the first step, **"Diagnosis and Pathology"**, the imported scan was reviewed in the axial, sagittal and coronal planes. The software has the ability to present a 3D reconstructed view in which the transparency of the images of the teeth can be changed (Figure 6).

In the next step, **"3D Tooth Anatomy"**, the canine was selected and the entire volume was cropped to leave only the data of interest (Figure 7a). In Step 3, **"Canal System"**, the number of root canals was identified and each root canal was then mapped separately by identifying the orifice and radiographic apical foramen of each root canal.

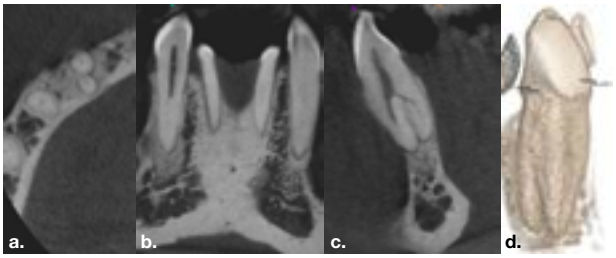

Figure 6. The imported scan reviewed in the axial (a), sagittal (b), and coronal (c) planes; (d) a 3D reconstruction view permitted by the software in which the transparency of the teeth can be changed.

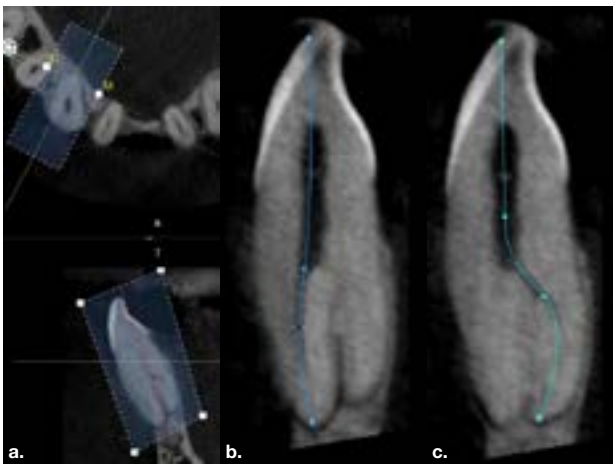

Figure 7. (a) Selection of the tooth to be examined; after identification of the canal orifices and radiographic apical foramina, corrections that were made for the buccal (b) and lingual (c) root canals according to the canal configuration which could be viewed in different planes by manipulating the software.

In Step 4, **"3D Canal Anatomy"**, the software made a proposal of the canal anatomy and corrections were made according to the canal configuration after viewing in different planes in the software. Figures 7b-c show the mapping of the buccal and palatal root canal systems.

At the final step, **"Treatment Plan"**, the software projected ISO size 06 instruments into the canals, which allowed both visualisation of the internal anatomy of the canals and the checking of straight-line access. This view was also rotated in 3D to alert us about the angle and direction of curvatures in the root canal systems. Figures 8a, and 8b (p511) present a view of the file curvatures for a conventional lingual access cavity preparation compared with a modified labial access cavity, respectively.

These simulations illustrate the lowest stress on the instruments during glide path preparation and canal preparation when a labial access cavity is prepared.

A master file can also be selected from a preloaded database of endodontic file systems. On the basis of the S-shaped curvatures in the lingual root canal system a decision was made to use the Small WaveOne Gold file (20/07) for root canal preparation in both canals (Figure 8c).

The selected instruments were then displayed in the root canal systems and these images could have also been digitally rotated to enable the operator to visualise the root canal anatomy in 3D.

The findings of the 3D Endo Software were taken into consideration and an access cavity was prepared on the labial aspects of both teeth. It was very easy to locate both canals in the canine as a result of the straight-line access obtained from the labial access cavity (Figure 9a).

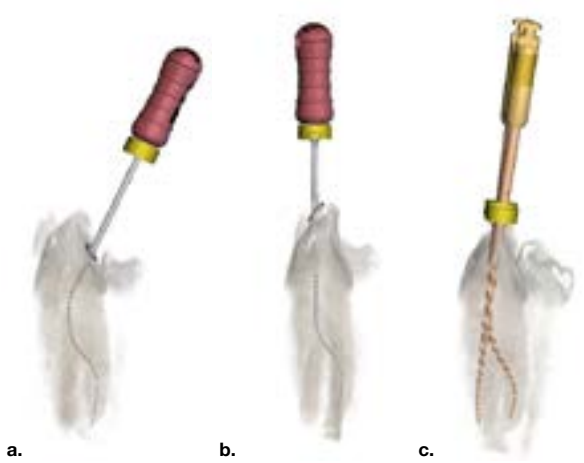

Figure 8. The software projection of ISO size 06 instruments into the canals, which allows the operator to visualise the internal anatomy of the root canals. (a) View of the file curvatures for a conventional lingual access cavity preparation; (b) view of the file curvatures for a modified labial access cavity; (c) Two WaveOne Gold Small files selected from a preloaded database of endodontic file systems and projected in the root canal systems.

Figure 9. (a) Location of both root canals in the two-rooted canine tooth; (b) periapical radiograph showing the result after root canal obturation of the two root canals in the canine and the single root canal in the lateral incisor; (c) 30-degree mesial angulated radiographic view of the canine showing the two obturated root canals in the canine, as well as two lateral canals branching off from each root canal system.

After glide path preparation with the reciprocating WaveOne Gold glider (Dentsply Sirona), the two root canals in the canine were prepared with a Small 20/07 WaveOne Gold file and the single canal in the lateral incisor was prepared with a Primary 25/07 WaveOne Gold file.

After irrigation, WaveOne Gold Gutta-Percha points were fitted and verified radiographically. Figure 9b shows the final result after root canal obturation of the two root canals in the canine and the single root canal in the lateral incisor.

DISCUSSION

A 30-degree mesial angulated radiographic view of the canine shows the two obturated root canals, as well as the two lateral canals branching off from each root canal system (Figure 9c, below).

The mandibular canine is considered to be the second longest tooth in the dentition, the maxillary canine being approximately 1 to 2 mm longer from the incisal edge to the most apical point. Clinical observation of mandibular canines has revealed a second root in some cases, which creates a unique morphology of a mandibular anterior tooth with a buccal and lingual root.

An important fact to consider, then, is that often two canals can be present in the lower canine and that, often but not always, these canals join into a single root canal system before exiting at the apex.[42] A further relevant anatomical feature is that the root canal of the mandibular canine appears to be flatter compared with its counterpart in the maxilla.

As discussed earlier, variations in the morphology of the mandibular canine exist and the available literature has even reported variations between populations.[7,8,11-17] Morphological variations (including the two-rooted mandibular canine) can present severe endodontic challenges during cleaning, shaping and obturation.[42]

The first step needed for proper cleaning and shaping of the root canal system is adequate access. Proper access also ensures excellent 3D obturation. In Case Report 2 of this study, endodontic access was gained through the labial surface of the tooth. Endodontic access cavities through the labial surface (rather than the traditional approach from the lingual side) may contribute towards the achievement of proper disinfection of root canal systems of lower anterior teeth.[43]

Mauger and co-workers observed proper straight-line access in 179 teeth. These authors concluded that in 27.6% of lower anterior teeth, ideal straight-line access was present slightly labial of the incisal edge.

The remaining 72.4% of observed teeth indicated ideal straight-line access through the incisal edge. According to the findings of their study, no straight line access was possible through the lingual surface.[44]

A buccal approach ensures conservation of valuable tooth structure near the cingulum area. An effort to retain tooth structure in this area is vital for strength of the clinical crown, the prevention of fractures and ultimately ensuring longevity of the endodontic treatment.[45] Labial access preparations often do create challenges with regard to aesthetics, but modern restorative approaches and available materials ensure a more predictable outcome.[46]

Radiographic imaging plays a vital part in diagnosis, treatment planning and follow up of modern endodontics.[47] High-resolution CBCT images are ideal for the diagnosis of periapical lesions, the identification of root fractures, resorption lesions, the evaluation of root canal morphology, root length and root curvatures.[48,49]

In addition, Dentsply Sirona recently introduced 3D Endo Software to the endodontic community. This remarkable innovation allows the clinician to perform pre-endodontic treatment planning of simple and complex endodontic cases. Digital Imaging and Communications in Medicine (DICOM) data from a CBCT scan is used to create a 3D image. Further benefits of the software are the identification of anatomical complexities, access cavity design, working length measurement, and identification of canal curvatures.[41]

The planning of endodontic cases in 3D has proved to be a major step forward for predictable modern endodontics.[40] 3-D imaging can also aid in the prevention of procedural errors, especially encountered in complex cases.[40]

The benefits of 3D Endo Software were demonstrated in Case Report 3. The software system proved to be a vital tool for pre-operative planning and also reduced complications during the procedure. The system allowed the creation of an ideal access cavity preparation, as well as the selection of the appropriate endodontic file system needed to obtain a predictable result.

CONCLUSIONS

The case reports in the study demonstrate a novel approach to cleaning, shaping and obturation of the mandibular canine with two roots and two root canals. Case Report 1 illustrates traditional access on the lingual surface. Case Reports 2 and 3 illustrate the benefit of the buccal approach to access and the incorporation of 3D endodontic software. A combination of altered endodontic access and innovative endodontic technology is an important consideration in the approach to treatment of mandibular canines with altered morphology.

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Do the CPD questionnaire on page 536

The Continuous Professional Development (CPD) section provides for twenty general questions and five ethics questions. The section provides members with a valuable source of CPD points whilst also achieving the objective of CPD, to assure continuing education. The importance of continuing professional development should not be underestimated, it is a career-long obligation for practicing professionals.

Online CPD in 6 Easy Steps

1 Go to the SADA website www.sada.co.za.

2 Log into the 'member only' section with your unique SADA username and password.

3 Select the CPD navigation tab.

4 Select the questionnaire that you wish to complete.

5 Enter your multiple choice answers. Please note that you have two attempts to obtain at least 70%.

6 View and print your CPD certificate.