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Assessment of endodontic treatment of c-shaped root canals

KEY WORDS

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SUMMARY

This communication presents the treatment of 15 cases of c-shaped canals in molars and their treatment outcome with two different obturation methods. The data from 901 patients who received root canal treatment in a molar tooth were examined regarding c-shaped root canals, their treatment and their status one year post op. Among the 901 cases, 15 molars had a c-shaped

root canal morphology (1,66%). C-shaped canals occurred mainly in second mandibular molars (73,3%). The obturation was either performed with gutta-percha and sealer (5 cases) or with Mineral Trioxide Aggregate as apical plug (MTA; 10 cases). All cases reached a symptomless status clinically and 14 cases showed apical healing in the radiographic control.

Introduction

Since the first reports of c-shaped root canal configurations in 1979 BY COOKE & COX, numerous investigations in this field have been conducted. There is data available regarding etiology, epidemiology, anatomical and radiographic classification, diagnostics, endodontic treatment and obturation (JAFARZADEH & WU 2007). Due to significant ethnic variation in the frequency of this anatomical characteristic, dentists need information about the frequency with which it occurs in their population. The first aim of our study was to retrospectively analyse endodontically treated molars with regard to the occurrence of c-shaped canals.

Furthermore, very little data is available for endodontic treatment methods in shaping and obturating c-shaped root canal systems. For obturation with gutta-percha, only information from case reports and one *in vitro* study is available (RICUCCI ET AL. 1996, WALID 2000, LYNN 2006, ORDINOLA-ZAPATA ET AL. 2009). There is no data available for the obturation of c-shaped canals with Mineral Trioxide Aggregate (MTA) except for a single case report about the successful treatment of a strip perforation in a c-shaped canal using MTA. Due to positive studies and reports on the usage of MTA in canals with wide apical aperture (MATT ET AL. 2004, BOGEN & KUTTLER 2009) we changed our treatment protocol

for c-shaped canals by integrating MTA in the obturation process. The second aim of this investigation was to retrospectively analyse the treatment outcomes in the endodontic management of c-shaped canals with different obturation techniques.

Materials and Methods

Overall 901 patients from a private practice in northern Germany (Hamburg) having received a root canal treatment (RCT) in a molar tooth during the period between August 2001 and May 2008 were retrospectively analysed. During these years the appearance of c-shaped canals was documented in the chart. There were no exclusion criteria. All of the patients were referred by another dentist for root canal treatment.

Treatment protocol

In instances where a built-up filling was missing, the tooth received a filling with core paste (DenMat, Orange, CA, USA). For each of the patients a rubber dam (SDS, Jarplund-Wedding, Germany) and a dental microscope at 25× magnification (OPMI 1 FC & OPMI PROegro, Zeiss, Oberkochen, Germany) were used. Identification of a c-shaped configuration was done by visual means assessing the pulp floor with a dental microscope for an isthmus between the canals. When maxillary molars were to be treated, attention was paid during EDTA rinsing as to whether the liquid was passing from one canal to the other. In order to reduce unnecessary radiation, no further radiographs prior to treatment were made.

Canal shaping

After preparing an access cavity, the coronal parts of the root canals were flared using Gates-Glidden-Burs (G180.204.S, 90 mm and 110 mm, Komet, Lemgo, Germany), and the working length was determined using an electronic apex locator (Root ZX, Morita, Osaka, Japan). Working length was confirmed with a radiograph. At the beginning of the study, the shaping was performed by nickel-titanium files (06-060 ISO Hedström, VDW, Munich, Germany) and rotary instruments (30.06, 35.06, 40.06 Flexmaster, VDW, Munich, Germany), and later with a newer NiTi rotary system (Mtwo System, VDW, Munich, Germany). For all of the treatments ultrasonic devices were used for apical preparation in decreasing order (ET18D, ET20, ET25, ET25S, ET BD, ET PR, Aceton, Bordeaux, France). Finally, two millimeter non-diamond coated ultrasonic tips were used until the apical aperture was visible. All teeth were treated with calcium hydroxide for a period of two weeks (Ultracal, Ultradent, South Jordan, UT, USA). The root canal dressing was covered with Cavit (3M ESPE, Seefeld, Germany) and a temporary resin filling (EcuSphere Carat, DMG, Hamburg, Germany).

Irrigation Regimen

The rinse protocol included a working rinse with sodium hypochlorite (5,25%) and a final rinse with EDTA (17%). In cases involving infected canals or requiring retreatments a further rinse with Ethanol (90%) and CHX (2%) was conducted. Since 2005, the sodium hypochlorite rinse was ultrasonically activated.

Obturation

Two different methods of obturation were used for c-shaped canals: the first method was a combination of lateral and vertical compaction techniques with gutta-percha and sealer (AH Plus, Dentsply, Konstanz, Germany). For this method a central master point of gutta-percha with sealer was condensed

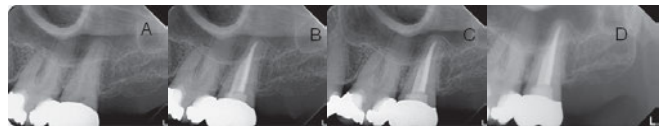


Fig. 1 Radiographic control: preoperative situation (A), obturation (B), one year after treatment (C), four years after treatment (D). This case was apically obturated using gutta-percha and sealer.

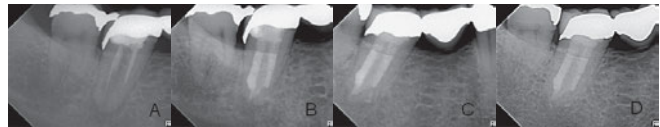


Fig. 2 Radiographic control: preoperative situation (A), obturation (B), one year after treatment (C), four years after treatment (D). This case was apically obturated using MTA.

in the lateral direction and the resulting space was filled with smaller points of gutta-percha. Subsequently, the points were sectioned with a hot plugger (System B, Analytic technology, Redmond, WA, USA). The viscous gutta-percha was vertically condensed with a plugger (Machtou Pluggers No 1/2, No 3/4, Dentsply, Konstanz, Germany). The procedure was stopped 4 millimetres pre-apical and the coronal part was filled with thermoplasticized gutta-percha and vertically condensed (Fig. 1).

Due to a change in the obturation protocol, the second method included apical filling with Mineral Trioxide Aggregate (ProRoot MTA, Dentsply, Konstanz, Germany). The MTA was mixed according to the manufacturer, placed just before the apex and condensed with an ultrasonically activated plugger. Each tooth was temporarily sealed with a sponge, Cavit and a temporary resin filling for four to seven days to ensure that the MTA had set. After reopening the canals were rinsed again and filled by way of a warm vertical technique with gutta-percha and sealer (Fig. 2). Both methods included a final resin filling. The final post-endodontic restoration, similar to a crown, was recommended to the patients but performed by the referring dentist.

Follow-up examination

The follow-up included clinical examination in the form of testing the percussion, palpation, pocket depth, mobility, coronal restoration and included a post-operative, controlling radiograph from one to four years after the treatment (Figs. 1 and 2). The radiographically diagnosed finding was subdivided into the following categories: healed, reduced radiolucency, no change in radiolucency, and increased or new apical radiolucency. A successful treatment was noted when the tooth showed no symptoms and at least a reduction in the apical radiolucency could be seen one year post treatment. Failure was noted when the tooth showed symptoms, no change, or new or increased apical radiolucency. The clinical and radiographical evaluation was done by one author (MB).

Results

Out of a total of 901 treated molars, 15 cases (1,66%) with a c-shaped canal morphology were found. Five teeth were found in male and ten cases in female individuals, with an average age of 47,53 years and a range of 32 to 68 years. All patients were of Caucasian descent. Of these 15 cases, four cases had already been endodontically treated and thus received retreatment.

Out of 443 maxillary molars that were treated, three teeth included a c-shaped canal (0,67%), and of 458 mandibular molars, twelve cases of c-shaped canals could be found (2,6%).

The c-shaped canal morphology was found more often in second mandibular molars. Only one case each could be found in first molars and wisdom teeth.

Treatment results/outcomes

In the follow-up each of the cases had reached a symptomless status after performing RCT with the methods detailed above. In the group of treated teeth with a prior diagnosis of pulpitis four cases could be classified as healed (3 MTA, 1 gutta-percha). The group of teeth diagnosed as having an apical periodontitis consisted of three cases obturated with MTA (all classified as being reduced in radiolucency after one year) and two cases obturated exclusively with gutta-percha and sealer (all cases classified as healed after one year). In the group of teeth diagnosed with chronic apical periodontitis, four cases were treated using MTA as apical plug (2 classified healed, 2 cases classified as reduced in radiolucency) and two cases were obturated with gutta-percha and sealer. Of these, one case could be radiographically classified as healed, while one case showed no change in apical radiolucency. In three of the five gutta-percha cases the sodium hypochlorite has not been ultrasonically activated.

Discussion

Frequency

In a collection of 901 treated molars, 15 teeth with a c-shaped root canal configuration could be found (1,66%). From 160 mandibular second molars, 6,87% showed this configuration. Recent publications have shown that the frequency of c-shaped root canals in mandibular second molars can be highly diverse, ranging from 2,7% (USA), 4,6% (Greece), 29% (China) to 44,5% (Korea) (AL SHALABI ET AL. 2000, DE MOOR 2002, CLEGHORN ET AL. 2006, SINGLA & AGGARWAL 2010, ZHENG ET AL. 2011). We found a notably high rate of maxillary second molars (1,25% of 160 teeth) in comparison to current literature, where just one case report could be found (SINGLA & AGGARWAL 2010). Regarding the mandibular first molars and maxillary third molars no cases could be found. The frequency of c-shaped canals in maxillary first molars with 0,35% of 279 teeth is comparable to the findings in other studies, with values differing from 0,09% to 1,2% (AL SHALABI ET AL. 2000, DE MOOR 2002, CLEGHORN ET AL. 2006). In the group of mandibular third molars a higher frequency of 4,5% (of 22 teeth) could be found in comparison to that of SIDOW ET AL. (2000), which showed a value of 2,2%. It must be pointed out that different diagnostic tools may differ in their sensitivity of detecting c-shaped canals and that this can lead to disparities in the detected rates. The present study represents the first data looking at the frequency of c-shaped root canals in a German and consequently European population. Regarding the correct diagnosis of root canal morphology, in the present study all c-shaped configurations were identified with the help of a dental microscope. Radiographs of these teeth allowed a suspected diagnosis of this configuration, but were not used to further classify the teeth as in Fan's classification (FAN ET AL. 2008). The value of two-dimensional radiograph in diagnosing c-shaped canal configurations has been controversially discussed (COOKE & COX 1979, OMER ET AL. 2004, JAFARZADEH & WU 2007, FAN ET AL. 2008, JUNG ET AL. 2010), whereas it is possible to get a suspected diagnose using this method (JAFARZADEH & WU 2007). New radiographic technologies, like

cone beam computed tomography (CBCT), offer a good possibility of preoperatively diagnosing special canal morphologies. However, this method should be reserved for special cases due to its higher radiation dose (PATEL ET AL. 2007). Other methods of c-shaped canal detection such as the crosscut section method, dye infiltration method or transparent model method (JIN ET AL. 2006) are limited to extracted teeth and in vitro studies.

Treatment

All c-shaped canals were treated by the same investigator (MB). The canals were cleaned with rotary instruments assisted by ultrasonic preparation and irrigation, which is a sufficient method of cleaning (CHEUNG & CHEUNG 2008). Due to a change in the obturation protocol (the availability of MTA for large apical apertures), two different obturation techniques were used over the course of these seven years. Five cases were obturated with thermoplasticized gutta-percha and sealer and ten cases were obturated with an apical plug of MTA, thermoplasticized gutta-percha and sealer. There are several modifications described in the use of thermoplasticized gutta-percha, although there are still difficulties in filling special anatomical varieties (JAFARZADEH & WU 2007, ORDINOLA-ZAPATA ET AL. 2009). The use of MTA in endodontic treatment is a method which has shown promising properties with regard to microleakage, biocompatibility and treatment results (ROBERTS ET AL. 2008). Only a few cases of endodontic treatment of c-shaped canals with especially the use of MTA as an obturation method have been described in the literature (TSAI ET AL. 2006, JAFARZADEH & WU 2007). In the ten present cases, MTA was used in combination with an ultrasonically activated plugger in order to take advantage of the thixotropic effect and achieve solid compaction and allocation of the material. All our endodontically treated cases with c-shaped canals showed full signs or trends of healing one year post intervention. Due to the endodontically specialized structure of the practice, most patients had been referred from other practices and did not take part in the follow-up.

Limitations

Retrospective case series have inherent disadvantages, including the fact that it is difficult to control many important factors. However, there is an advantage in the ability to generate large cohorts and to investigate a characteristic which only occurs with a low incidence. With the limited significance of 15 treated cases it can only be assumed that both obturation techniques (gutta-percha + sealer or MTA, gutta-percha + sealer) are sufficient methods for obturating c-shaped root canals. Due to the small number of cases and the number of variables involved, no further sufficient statistical considerations could be made. For example, in three of the five gutta-percha cases the sodium hypochlorite has not been ultrasonically activated. Another possible bias can be seen in this being a special patient collection due to the fact that all of the patients were referred from a general dentist to a specialized practice.

Further investigations are required on the occurrence of c-shaped canals because of their low prevalence. This should be achieved through multicentre studies or the respective analysis of CBCTs. The prevalence of c-shaped canals in the German population is not very high (1,7%). Due to our small sample size we can only suspect that obturations with gutta-percha as well as obturations with MTA for c-shaped canals are appropriate methods of treatment.

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Résumé

La fréquence d'apparition de canaux radiculaires en forme de C présente une grande variabilité entre les différentes catégories de la population et constitue souvent un défi pour le traitement endodontique. Jusqu'à présent, il n'existait guère d'informations concernant la fréquence de cette configuration dans les régions caucasiennes ainsi que sur les options thérapeutiques. L'objectif de cette enquête était d'examiner la fréquence d'apparition de canaux radiculaires en forme de C sur molaires ainsi que de comparer rétrospectivement deux méthodes d'obturation. Au total, 901 traitements endodontiques réalisés sur des molaires ont été analysés entre 2001 et 2008 dans la région de l'Allemagne du Nord. Le traitement endodontique suivait un protocole standardisé: après trépanation, chaque dent était inspectée sous microscope opératoire, et de l'hydroxyde de calcium était appliqué comme médication intracanalairale initiale. Tous les canaux en C étaient préparés par des pointes ultrasoniques dans leur tiers apical. Les examens radiologiques et cliniques (percussion, palpation, mobilité, sondage parodontal, examen de l'obturation coronaire) de ces canaux ont été évalués dans les 12 mois après le traitement endodontique. Sur 901 molaires examinées, 15 d'entre elles présentaient une configuration en C (1,66%), avec une répartition de 3 sur 443 molaires supérieures (0,67%) et 12 sur 458 molaires inférieures (2,6%), 73,3% se retrouvant dans la deuxième molaire inférieure. Seule une première molaire supérieure et une troisième molaire inférieure avaient une configuration canalaire en C.

Avant 2004, l'obturation de canaux avec apex ouvert était exécutée par condensation verticale de Gutta Percha et Sealer (5 cas). En regard de données scientifiques favorables à l'obturation au MTA (Mineral Trioxide Aggregat), des canaux présentant des apex ouverts, le protocole d'obturation a été changé en 2004 (10 cas). Pour ces cas, on attendait toujours le durcissement du matériel MTA, après quoi l'obturation des $\frac{2}{3}$ coronaires par Gutta Percha et Sealer en condensation verticale était effectuée lors d'une séance ultérieure.

Lors des contrôles postopératoires, toutes les molaires en C étaient asymptomatiques. L'examen radiologique, toujours effectué par le même examinateur, était classifié en quatre catégories: «guéri», «foyer en diminution», «pas de changement du foyer», «croissance ou nouveau foyer». Dans 14 cas, une cicatrisation osseuse de la lésion apicale a été observée radiologiquement. Seule une dent traitée par Gutta Percha et Sealer ne témoignait d'aucune amélioration au niveau du foyer apical.

Au vu du caractère rétrospectif de l'étude et du nombre limité de dents radiculaires en C étudiées, la conclusion que les deux méthodes d'obturation présentaient le même succès est à prendre avec précaution. Il est néanmoins à noter la relativement faible fréquence (1,66%) de canaux radiculaires en C au niveau des molaires dans la population allemande.

Zusammenfassung

Die Häufigkeit von c-förmigen Wurzelkanälen variiert stark zwischen den verschiedenen Bevölkerungsgruppen und stellt in den meisten Fällen besondere Anforderungen an die endodontische Behandlung. Bisher gibt es nur wenige Informationen zur

Häufigkeit von c-förmigen Kanälen im kaukasischen Raum und wenige klinische Informationen über verschiedene Therapiemethoden. Das Ziel der vorliegenden Untersuchung war es, die Häufigkeit des Auftretens von c-förmigen Wurzelkanälen in Molaren zu untersuchen und zwei verschiedene Obturationsmethoden in der Therapie von 15 behandelten c-förmigen Wurzelkanälen retrospektiv zu vergleichen. Insgesamt wurden 901 wurzelkanalbehandelte Molaren, die in einem Zeitraum zwischen 2001 und 2008 in einer zahnärztlichen Praxis im norddeutschen Raum behandelt wurden, auf das Vorkommen einer c-förmigen Kanalkonfiguration hin untersucht. Die Therapie der Zähne erfolgte nach einem standardisierten Protokoll. Alle behandelten Zähne wurden nach Trepanation mithilfe eines Mikroskops visuell inspiziert und erhielten initial eine temporäre medikamentöse Einlage mit Kalziumhydroxid. Bei Verdacht auf das Vorliegen von c-förmigen Wurzelkanalkonfigurationen anhand des Ausgangsröntgenbildes erfolgte eine visuelle Kontrolle und Bestätigung mithilfe des Dentalmikroskops. Alle c-förmigen Kanäle wurden im apikalen Wurzel-drittel mithilfe von Ultraschallspitzen präpariert. Die behandelten Zähne wurden innerhalb eines Jahrs in Bezug auf den klinischen und radiologischen Status nachuntersucht. Die klinische Inspektion beinhaltete jeweils einen Perkussionstest, Palpation, Lockerung, Erhebung der Sondierungstiefen und Kontrolle des koronalen Verschlusses. Von 901 endodontischen Behandlungen an Molaren wiesen 15 Zähne eine c-förmige Kanalkonfiguration auf (1,66%). Innerhalb dieser Gruppe zeigte der zweite untere Molar dieses anatomische Merkmal mit 73,3% am häufigsten. Von 443 Molaren im Oberkiefer konnte in 0,67% (3 Molaren) ein c-förmiger Kanal festgestellt werden, von 458 Molaren im Unterkiefer waren es 2,6% (12 Molaren). Beim ersten Oberkiefermolar und beim dritten Unterkiefermolar konnte jeweils nur ein Fall gefunden werden. Aufgrund der positiven Ergebnisse von Mineral-Trioxide-Aggregaten (MTA) in der Studienlage zur Obturation von Wurzelkanälen mit weitem apikalem Lumen erfolgte 2004 eine Änderung des Obturationsprotokolls: Der Verschluss des aufbereiteten und desinfizierten Wurzelkanals wurde bis dahin mittels vertikaler Kondensation von Guttapercha und Sealer (5 Fälle) und danach mittels apikalem MTA durchgeführt (10 Fälle) erstellt. Im Fall der apikalen MTA-Applikation erfolgte immer eine zweite Sitzung bis zur Aushärtung des Materials, in der eine weitere vertikale Füllung mit Guttapercha und Sealer und der definitive koronale Verschluss erfolgten. Alle Fälle waren nach der Behandlung symptomlos. Die radiologische Auswertung wurde in die Kategorien «geheilt», «verringerte Aufhellung», «keine Veränderung der Aufhellung» oder «neue oder Zunahme der apikalen Aufhellung» eingeteilt und erfolgte immer durch denselben Prüfer. In 14 Fällen konnten radiologische Zeichen einer apikalen Konsolidierung festgestellt werden. Ein Zahn aus der Guttapercha-Gruppe zeigte keine Veränderung der Aufhellung. Aufgrund des retrospektiven Charakters der Studie, der damit einhergehenden Limitationen sowie der geringen Fallzahl lassen sich nur bedingt Vergleiche zwischen den beiden angewendeten Obturationsmethoden ziehen. Mit beiden Wurzelkanalfülltechniken wurden erfolgreich Behandlungen durchgeführt. Die Studie zeigt, dass die Häufigkeit von c-förmigen Wurzelkanälen in Molaren in der deutschen Bevölkerung mit 1,66% relativ gering ist.

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