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Outcome Assessment of Endodontic Treatment of Mandibular Second Molars with C-shaped Canals in Elderly Patients

Yu-Ra Go, Mi-Yeon Kim, Sun-Ho Kim, Jeong-Hee Kim, Ran-Ah Kim

Department of Conservative Dentistry, Veterans Health Service Medical Center, Seoul, Korea

Purpose: The aim of this study was to investigate the outcomes of endodontic treatment of mandibular second molar with C-shaped canal in elderly patients and related factors affecting the survival of the tooth.

Materials and Methods: From 2010 to 2015, the survival rate following endodontic treatment was evaluated in elderly patients over 60 years who visited the Veterans Health Service Medical Center for endodontic treatment. The presence of C-shaped canals was confirmed using clinical records and radiographic features. Patient's age, sex, systemic diseases, tooth location, vitality, signs and symptoms, fractures, caries, apical radiolucency, canal shaping methods, sealer leakage, filling voids, and restoration of prosthesis were included in the analyses as confounding variables. The survival rate of teeth was analyzed using Kaplan–Meire analysis and the relationship between the survival rate and variables was analyzed using Simple and Multiple Cox regression analysis.

Result: In total, 107 teeth in elderly patients had C-shaped canal. The survival rate of teeth that received endodontic treatment was 63.70%. None of the factors investigated significantly influenced the survival rate (P>0.05).

Conclusion: In elderly patients with C-shaped canal, the survival rate after root canal treatment was not significantly different from that of other mandibular molars.

Key Words: Aged; C-shaped canal; Root canal therapy; Survival rate

Introduction

Research on C-shaped canals has continued since Keith and Knowles[1] first reported observations of C-shaped roots and canals in Neanderthal skeletons in 1908 and 1911. C-shaped canals cause difficulties in endodontic treatment due to their anatomical complexity and configuration. Cooke and Cox[2] reported that C-shaped canals were difficult to diagnose due to the thin areas where the roots were intercon-

Corresponding Author: **Ran-Ah Kim**, https://orcid.org/0000-0002-4718-8376
Department of Conservative Dentistry, Veterans Health Service Medical Center, 53 Jinhwangdo-ro 61-gil, Gangdong-gu, Seoul 05368, Korea
TEL : +82-2-2225-1925, FAX : +82-2-2225-3929, E-mail : sksdk16@naver.com

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nected. Although most C-shaped canals show a pattern of adjoining or fused roots on periapical radiographs, they can appear as separate roots on radiographs[3]. These complexities of C-shaped canals cause difficulties in cleaning and shaping procedures in endodontic treatment. In order to facilitate complex treatment, self-adjusting files and nickel-titanium (Ni-Ti) rotating instruments have been used along with the development of ultrasonic devices[4]. Despite all those efforts, however, the treatment of C-shaped canals is still challenging, affecting treatment outcomes. Since the prevalence of C-shaped canals is quite high in Koreans (31.3% to 45.4%), clinicians with limited experience in the endodontic treatment of mandibular molars with C-shaped canals need thorough understanding on the proper treatment strategies and resultant prognosis[5,6].

A recent study reported that the number of elderly people aged 60 years or older in the world is projected to increase to 1.4 billion by 2030, and according to Statistics Korea, the number of elderly people aged 65 years or older is expected to increase to 39.9% of the total population of South Korea in 2040[7]. According to the National Health Survey, the proportion of dental care visits among the elderly is higher than among other age groups. As life expectancy increases, so does elderly patients' interest in the preservation of their teeth and desire for root canal treatment. The endodontic treatment of elderly patients requires considering their previous disease history, as well as physiological and morphological aging of the dentin and pulp. As age increases, closure of dentinal tubules and root canal calcification may occur[8]. These are attributable to dentinal sclerosis and restorative dentin caused by dental caries, abrasion, attrition, and trauma for a long period of time[9]. Although a root canal appears to be absent on radiographs, some pulp residue or less calcified passages can cause pulp exposure and tooth pain[10]. In addition, a history of systemic hypertension and diabetes, which are frequently present in elderly patients, can affect treatment outcomes[11].

Although many studies have investigated the prevalence[12-14] and anatomical configurations[3] of C-shaped canals, insufficient research has analyzed the results of endodontic treatment of C-shaped canals; in particular, no studies have described the treatment results in elderly patients. Therefore, the aim of this study was to investigate the outcomes of endodontic treatment of mandibular second molars with C-shaped canals in elderly patients.

Materials and Methods

Among the patients who visited the Veterans Health Service Medical Center (VHS Medical Center, Seoul, Korea) and received endodontic treatment due to irreversible pulpitis and pulp necrosis between 2010 and 2015, a total of 825 mandibular second molars in 815 patients who had more than 1-year follow-up period were preliminarily enrolled in the study. Among them, elderly patients aged 60 years or over were selected as subjects of this study. Exclusion criteria included the condition if the treatment had been discontinued, if they had severe underlying diseases or a history of systemic operations that prohibit endodontic treatment, or if the endodontic treatment had been started at another hospital. The procedure for this study was approved by the Institutional Review Board of the VHS Medical Center (BOHUN 2020-02-011).

Examiners confirmed the presence of C-shaped canals using medical records, periapical radiographs, and cone-beam computed tomography. If the canals of the mandibular second molar merged into one main canal or appeared to be conical on the radiographs, they were classified as C-shaped canals. If it was not possible to confirm the C-shaped canal using the above methods, final confirmation was made using a radiograph taken after inserting a file into the canal according to the method described by Weine[15].

As preoperative factors, patients' age, sex, systemic disease history, tooth location, the presence of pulp vitality, symptoms, fractures, caries, and periapical lesions were investigated. Intraoperative factors included the number of visits and canal shaping methods, and as postoperative factors, the presence of sealer leakage, air bubbles in the filler, and prosthesis restoration were retrospectively evaluated.

All endodontic treatment procedures were performed under rubber dam isolation. Cavity preparation was performed via a straight-line approach using No. 330 bur (Mani, Tochigi, Japan) and a high-speed handpiece. The operative field was determined with an apex locator (Denta Ports DP-ZX; J. MORITA MFG. CORP., Kyoto, Japan) and periapical radiographs. Root canal shaping was performed using a K-file (Mani) and then a Ni-Ti rotating instrument or only a hand file (K-file, H-file) according to the manufacturer's instructions. The root canal was washed with 5.25% NaOCl and a 27-G syringe (Pac-Dent International. Inc., Brea, CA, USA) during canal shaping. Root canal filling was then performed using the continuous wave technique or the lateral compaction using AH Plus sealer (Dentsply Tulsa Dental, Tulsa, OK, USA) and gutta-percha. After the root canal filling, the treatment was completed with resin core filling or resin core filling followed by crown restoration.

At each visit, the patient was asked about dental pain and underwent clinical and radiographic examinations. In accordance with the method of Lazarski et al.[16], failure was defined when a surgical procedure (including tooth extraction, repeated root canal treatment, or periapical surgery) was performed. If the tooth was maintained without any treatment, it was considered as survival. Kaplan–Meier analysis was performed to evaluate the survival rate of the teeth. To confirm the relationships of factors influencing the treatment outcomes, the associations between significant variables and the treatment outcomes were assessed using simple and multiple Cox regression analyses. All statistical analyses were performed using the R program with a 95% significance level, and P-values <0.05 were considered to indicate statistical significance.

Result

In a total of 815 patients, 825 mandibular second molars were investigated. Among the patients, 12.96% (107/825) were 60 years or older with C-shaped canals. The mean age of the patients included in the analysis was 72.29±17.7 years. The proportion

Table 1. Demographic and clinical characteristics of patients with C-shaped canals

Variable	Value
Sex	
Male	83 (77.57)
Female	24 (22.42)
Location	
Left	48 (44.85)
Right	59 (55.14)
Signs and symptoms	
Present	73 (68.22)
Absent	34 (31.77)
Radiolucency	
Present	27 (25.23)
Absent	80 (74.76)
Pulp vitality	
Vital	52 (48.59)
Nonvital	55 (51.40)
Caries	
Present	44 (41.12)
Absent	63 (58.87)
Fracture	
Present	26 (24.29)
Absent	81 (75.70)
Hypertension	
Present	61 (57.00)
Diabetes mellitus	
Present	20 (18.69)
Cardiovascular disease	
Present	18 (16.82)

Values are presented as number (%).

of female patients with C-shaped canals was 22.42% (24/107), and the proportion of male patients was 77.57% (83/107). More than half of the C-shaped canals were found in right mandibular second molars (55.14%; 59/107), while 44.85% were found in left mandibular second molars (48/107). Most of the C-shaped canals (68.22%; 73/107) had symptoms before treatment, 25.23% (27/107) had radiographic lesions, and 48.59% (52/107) had pulp vitality. Teeth with caries accounted for 41.12% of those with C-shaped canals (44/107), and 24.29% had fractures (26/107) (Table 1). The mean follow-up period was 45.80±19.2 months.

Thirty-six teeth were finally extracted, and the cumulative survival rate of the teeth based on the Kaplan–Meier analysis is presented in Fig. 1. The survival rate of the teeth that received endodontic treatment was 63.70% up to 64 months. Table 2 shows the results of the simple and multiple Cox regression analyses performed to evaluate the influence of the examined factors on the survival rate. No factors were found to have a significant influence on the survival rate (P>0.05).

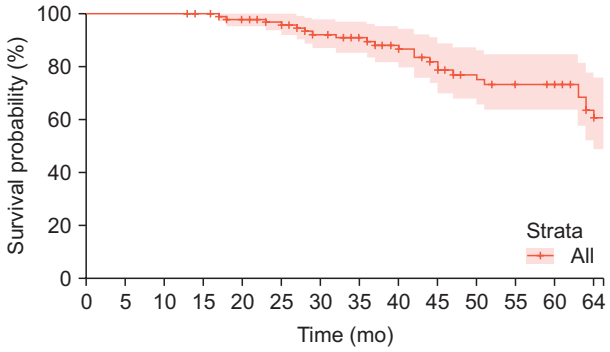

Fig. 1. Cumulative survival probabilities for teeth (Kaplan–Meier analysis).

Discussion

This study investigated the success rate of endodontic treatment of mandibular second molars with C-shaped canals in patients aged 60 years or older. A total of 107 teeth (12.96%, 107/825) had C-shaped canals. This prevalence was lower than that in the previous retrospective study on C-shaped canals in Koreans reported as 31.4% in 2009[17]. Extensive aging

Table 2. Simple and multiple Cox analyses of the contributing factors to the outcomes

Variable	Simple Cox regression		Multiple Cox regression	
	HR (95% CI)	P-value	HR (95% CI)	P-value
Age	0.96 (0.92~1.01)	0.108	-	-
Sex	0.96 (0.41~2.24)	0.922	-	-
Location	1.01 (0.52~2.38)	0.072	-	-
Sign & Symptom	1.62 (0.66~3.98)	0.293	-	-
Radiolucency	1.67 (0.82~3.41)	0.155	-	-
Pulp vitality	1.87 (0.92~3.78)	0.081	1.41 (0.58~3.44)	0.445
Caries	0.63 (0.30~1.34)	0.232	-	-
Fracture	1.17 (0.55~2.46)	0.686	-	-
Visit	1.31 (0.90~1.91)	0.157	-	-
Shaping	0.44 (0.16~1.20)	0.107	-	-
Sealer leakage	1.39 (0.64~3.04)	0.406	-	-
Void	0.40 (0.20~0.81)	0.104	0.66 (0.30~1.44)	0.296
Final restoration	1.07 (0.43~2.64)	0.885	-	-
Hypertension	0.79 (0.38~1.63)	0.524	-	-
Diabetes mellitus	0.65 (0.27~1.57)	0.334	-	-
Cardiovascular disease	2.80 (1.15~6.82)	0.231	2.73 (1.08~6.90)	0.334

HR: hazard ratio, CI: confidence interval, -: not available.

in the pulp and dentin complex can cause changes in the root canal structure[7]. Likewise, Manning[18] reported that the morphology of C-shaped canals changes due to dentin deposition in the root canal with age and that C-shaped canals are commonly found in those aged 40 years or younger[19,20].

In this study, the cumulative survival rate after endodontic treatment among elderly patients (aged 60 years or over) with C-shaped canals was 63.70%. In retrospective study with an observation period ranging from one to twenty years, it was reported that the success rate of root canal treatment was between 53.5% and 94.5%[21]. In 2016, Ahn et al.[22] reported a success rate of 70.9% in C-shaped canals. Similarly, in the study of Swartz et al.[23] that investigated the success rate of endodontic treatment, the success rate in patients 60 years or older was the highest, but there was no significant difference according to age. In the current study, the success rate was similar to those in other studies and there was no significant difference according to age. However, given that the reported average survival rate of endodontic treatment is between 85%~95%, the survival rate of this study is remarkably low[22,24]. Considering that most studies that evaluated healing outcomes have an average follow-up period of 1 year, with the longest follow-up period as 65 months, it is possible that the long term follow-up period may have lowered survival rate.

The factors investigated in this study did not affect the survival rate after endodontic treatment (P>0.05). Systemic diseases were relatively common in our study sample, as 61 patients had hypertension, 20 patients had diabetes, and 18 patients had cardiovascular disease (Table 1). The presence of absence of systemic disease also did not affect the survival rate. Previous studies reported a potential correlation between the etiology of some systemic diseases and that of root canal diseases[11]. In addition, both diabetes and hypertension were found to be significantly associated with a lower survival rate of endodontically treated teeth[25,26]. However, similar to this study, a systematic review that investigated systemic diseases and endodontic treatment results reported no significant association between diabetes and the results of endodontic treatment[27].

Of the teeth examined, 36 were extracted. Many of them were extracted due to vertical root fracture (14/36) (Fig. 2). Previous studies have suggested the risk of vertical root fractures was higher in teeth that

Fig. 2. Representative periapical radiographs of survived (A-C) and failed (D-F) endodontic treatment. (A, D) Preoperative, (B, E) after root canal filling, and (C, F) follow-up radiographs. J-shaped periapical lesion indicating vertical root fracture (F) was defined as non-survival and the tooth was extracted.

received endodontic treatment than those that did not[28,29]. The tooth microstructure changes with age. Specifically, the inorganic component increases and the organic component decreases[30]. These changes alter the mechanical and physical properties of teeth, making fractures more likely[31]. Previous research also reported that elderly patients had a 1.4-fold higher likelihood of tooth extraction after endodontic treatment than younger patients[32].

According to the increase of average age of a society, the demand for endodontic treatment among elderly patients is on the rise. For clinicians, endodontic treatment in elderly patients is considered a major challenge for reasons such as calcification of root canals, cognitive decline, and limited mobility. However, in this study, the survival rate of endodontic treatment in elderly patients aged 60 years or older with C-shaped root canals was not significantly different from the results of other studies, and none of the investigated factors significantly affected the survival rate. Since this study examined only elderly patients aged 60 years or older, further analyses on various age groups, endodontic treatment methods and materials should follow.

Conclusion

A significant aspect of this study was that it evaluated the survival rate of endodontic treatment of C-shaped root canals and associated factors in elderly patients aged 60 years or older. It is conceivable that the survival rate in this study may be comparable to that in the mandibular molars with normal anatomical structure or in younger age groups. Age-related changes in pulp and dentin should also be recognized before root canal treatment for elderly patients.

Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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