# A Retrospective Comparative Study on the Long-Term Outcomes of Root Canal Treatment in Mandibular First and Second Molars

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# A Retrospective Comparative Study on the Long-Term Outcomes of Root Canal Treatment in Mandibular First and Second Molars

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# ABSTRACT

## A Retrospective Comparative Study on the Long-Term Outcomes of Root Canal Treatment in Mandibular First and Second Molars

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Differences in success rates for mandibular molars may be influenced by their position in the dental arch and anatomical variations. C-shaped canals have been considered a major factor complicating root canal treatment, thereby lowering the success rate. This study aims to compare the long-term success and survival rates of endodontic treatment in mandibular first and second molars, analyze the impact of their position in the dental arch on success rates, and evaluate the effect of anatomical variations by comparing non-surgical root canal treatment in C-shaped and non C-shaped canals in mandibular second molars.

A clinical database was examined to identify patients who underwent nonsurgical root canal treatment on mandibular molars from 2005 to 2015. The clinical and radiographic records of each patient were reviewed. Two examiners assessed the periapical radiographs using the periapical index scoring system, and their agreement was evaluated. Chi-square tests were used to analyze the impact

of various factors on the success rate, while multivariable logistic regression analysis predicted the likelihood of different success outcomes. Kaplan–Meier statistics, log-rank tests, and the Cox proportional hazards model were utilized to compare survival rates between groups.

In total, 733 teeth were included in the study, consisting of 401 mandibular first molars and 332 mandibular second molars. The four-year success rate was 63.34% for mandibular first molars and 73.49% for mandibular second molars, showing a statistically significant difference between the two groups. No significant difference was observed between C-shaped and non C-shaped canals in mandibular second molars. Multivariate logistic regression analysis indicated that only the tooth number was significantly correlated with the success rate. Kaplan-Meier survival analysis and the log-rank test demonstrated a significantly higher survival rate for mandibular first molars compared to mandibular second molars. However, no significant difference was observed between C-shaped and non-C-shaped canals in mandibular second molars. Cox proportional hazards analysis showed lower survival rates after root canal treatment in mandibular second molars compared to first molars, but the difference was not statistically significant.

**Key words** : Nonsurgical endodontic treatment, Retreatment, Mandibular molars, C-shaped canals, Clinical outcome, Long-term study

# 1. Introduction

The success of endodontic procedures significantly impacts the patient's oral health, which is essential for maintaining the function and long-term survival of the teeth. Non-surgical root canal treatment includes initial root canal treatment(RCT) and retreatment(re-RCT), aiming to eliminate the source of infection within the root canal thus prevent and eliminate apical periodontitis. The outcomes of root canal treatments have been evaluated in various studies. Ng et al. reported success rates of 83% for initial root canal treatment (RCT) and 80% for retreatment (re-RCT) at a 2-4 year follow-up (Ng et al., 2011a). According to a retrospective cohort study by Kim et al., the 4-year success rates were 83.7% for RCT and 77.3% for re-RCT.(Kim, 2023) The 4-year cumulative tooth survival following RCT was 95.4% and re-RCT was 95.3%(Ng et al., 2011a). In population-based study in Korea, five-year survival rates for RCT and re-RCT was 90.85% and 88.42%, respectively(Kwak et al., 2019).

As follows, canal treatment can be regarded as a predictable procedure with consistently positive outcomes, but it does present some challenging elements. Anatomical variations, such as the presence of dens invaginatus, two palatal roots in maxillary molars, and four roots in mandibular first molars, can significantly increase the complexity of root canal treatment. (Siqueira et al., 2022). Anatomical variations in mandibular molars are diverse, with the C-shaped canal being a representative example. The primary anatomical feature of C-shaped canals is a fin or web that links the separate root canals. Since Cooke and Cox first identified and highlighted their potential clinical importance in 1979(Cooke & Cox, 1979), various studies have focused on the C-shaped canal system. The C-shaped canal, commonly found in the mandibular second molar, is a major factor that complicates root canal treatments and is classified as high difficulty in the AAE's endodontic case

difficulty guidelines(AAE, 2022). The complex morphology, especially the isthmus connecting the canals, can act as a reservoir for tissue debris, but the thin root thickness poses limitations for instrumentation and prosthetic treatment(Chhabra et al., 2014). This variation is most commonly found in Asians but occurs relatively infrequently in Europeans and Americans (Kato et al., 2014). The prevalence of C-shaped canals in the South Korean population was 36.8% and 39.8% based on CBCT analysis(Kim et al., 2018; Yang et al., 2021). In the study by Seo et al., which included clinical observation and in vitro research through sectioning of extracted teeth, the prevalence was 32.7%(Seo & Park, 2004). Examining whether the high prevalence of complex C-shaped canals is disadvantageous, Ahn et al. compared the healing rates of 79 C-shaped canals and 117 non C-shaped canals in mandibular second molars and reported no statistically significant difference in healing rates between the two groups(Ahn et al., 2016). However, the previous study has limitations as it had small sample size and a short follow-up period of an average of 24 months.

In evaluating the clinical success rates of endodontic treatment, various studies have identified the type of tooth as a significant variable. Among these, the success rate of endodontic treatment in mandibular molars is generally lower compared to maxillary molars(Kim, 2023; Ng et al., 2011b). Despite the disadvantages of maxillary molars, such as limited visibility during procedures and the presence of additional canals, the reasons for the lower success rate in mandibular molars have not been elucidated. This can be attributed to the mandibular second molar's posterior position in the dental arch, which complicates instrument access and increases the procedure's difficulty. Additionally, there is a higher prevalence of challenging C-shaped canals in these teeth. Due to their position in the dental arch and anatomical differences, it is expected that the outcomes of root canal treatments for these two teeth would vary. However, verification is needed as there have been few comparative studies that separate the mandibular first and second molars into distinct groups.

Therefore, this study aims 1) to compare the long-term success rates and survival rate of endodontic treatment in mandibular first and second molars, and 2) evaluate the effect of anatomical variations by comparing the endodontic treatment in C-shaped and non C-shaped canals in mandibular second molars.

# 2. Material & Methods

## 2.1. Subjects

This retrospective study was approved by the Yonsei University Committee for Research on Human Subjects (2004-4) and conducted within the Department of Conservative Dentistry, Yonsei University Dental Hospital. A clinical database was reviewed to identify patients who underwent nonsurgical root canal treatment (RCT) between 2005 and 2015. The clinical and radiographic data of each patient were thoroughly reviewed and evaluated based on distinct inclusion and exclusion criteria for success & failure outcome analysis and survival analysis as follows:

1. Success & Failure Outcome Analysis

- Inclusion Criteria:

  Mandibular molars that underwent nonsurgical root canal treatment, including both initial RCT and re-treatment (re-RCT).

  Teeth with sufficient follow-up data (minimum 4 years post-treatment).

- Exclusion Criteria:

  Teeth extracted for non-endodontic reasons within the follow-up period.

2. Survival Analysis

- Inclusion Criteria:

All cases of mandibular molars treated with nonsurgical root canal treatment.

Teeth with at least one follow-up record after treatment.

- Exclusion Criteria:

None (Teeth extracted for non-endodontic reasons were censored but included in the analysis).

**2.1.1. Identification of the morphology of a C-shaped root canal**

The identification of a C-shaped root canal was based on documentation in the medical records. In the absence of such documentation, the identification was made based on radiographic features as suggested by Fan et al. Fan et al. (2004). Mandibular second molars with conical or square-shaped roots, characterized by canals either converging into a single primary canal or divided by a longitudinal radiolucent line, were categorized as C-shaped.

## 2.2. Treatment protocol

The nonsurgical root canal treatments (RCT and re-RCT) were performed by faculty members and postgraduate students under the supervision of faculty. The procedures generally followed the American Association of Endodontists' (AAE) Guide to Clinical Endodontics, though not strictly adhering to a single protocol. All treatments were conducted under rubber dam isolation to prevent saliva contamination. After accessing the tooth, the coronal portion of the canals was flared before negotiating the apical portion and determining the working length. The root canal apex was located

using an electronic apex locator (Root ZX, Root ZX II by Morita, Japan). The working length was confirmed by both the electronic apex locator (EAL) readings and periapical radiographs. The apical portion of the canal was prepared using ProTaper NiTi files (Dentsply Tulsa Dental, Tulsa, OK, USA), the rotary K3 instrument system (Kerr US), and Profile NiTi files (Dentsply Tulsa Dental). Sodium hypochlorite (2.5-5%) was the primary irrigant, with EDTA (17% ethylenediamine-tetra-acetic acid) or 0.2% chlorhexidine gluconate used optionally in some cases. Calcium hydroxide paste [Calcipex II (Nishika Japan), Metapaste Plus (Meta Biomed Korea), Well-Paste (Vericom Korea)] was applied as an intracanal medicament between appointments. All root canals were filled with gutta-percha and either an epoxy resin-based sealer (AH-26, AH-26 Plus, Dentsply Sirona US), a calcium hydroxide-based sealer (Sealapex, Kerr US), or a zinc oxide-eugenol based sealer (Tubli-seal, Kerr US), using a technique chosen by the operator.

**Preoperative factors**

The patients' personal information, including age and gender, was documented. Details about the affected tooth, including its location, number of root canals, and the presence of a C-shaped canal, were gathered to identify the preoperative factors.

## 2.3. Radiographic evaluation

### 2.3.1. The periapical index(PAI) scoring system

Success rates were assessed by evaluating periapical radiographs taken at the follow-up closest to the 4-year mark. For cases monitored for over 4 years, the periapical radiograph assessed independently by two examiners (J. Y. and S. K.) using the periapical index (PAI) scoring system suggested by Ørstavik et al.(Orstavik et al., 1986). Figure 1 shows the periapical index (PAI) system using a 5-point ordinal scale, with scores ranging from 1 (indicating health) to 5 (indicating severe

periodontitis with exacerbating features). The guidelines for scoring cases using the PAI are as follows: 1) Identify the reference radiograph that most closely matches the periapical area under study and assign the corresponding score to the observed root. 2) If uncertain, assign a higher score. 3) For teeth with multiple roots, use the highest score among the individual roots. 4) Every tooth must be scored. Two reviewers calibrated the evaluation criteria before assessing the cases, and statistical analysis was conducted to measure inter-examiner reproducibility after evaluation. If there were discrepancies in the radiographic evaluation, the two examiners reached a consensus through discussions. To facilitate communication and comparison of results among studies, particularly follow-up studies, PAI scores were dichotomized: PAI 1 and 2 were considered successful, while PAI 3, 4, and 5 were considered failures. (Kirkevang et al., 2015; Ørstavik 1996; Ørstavik et al., 2004).

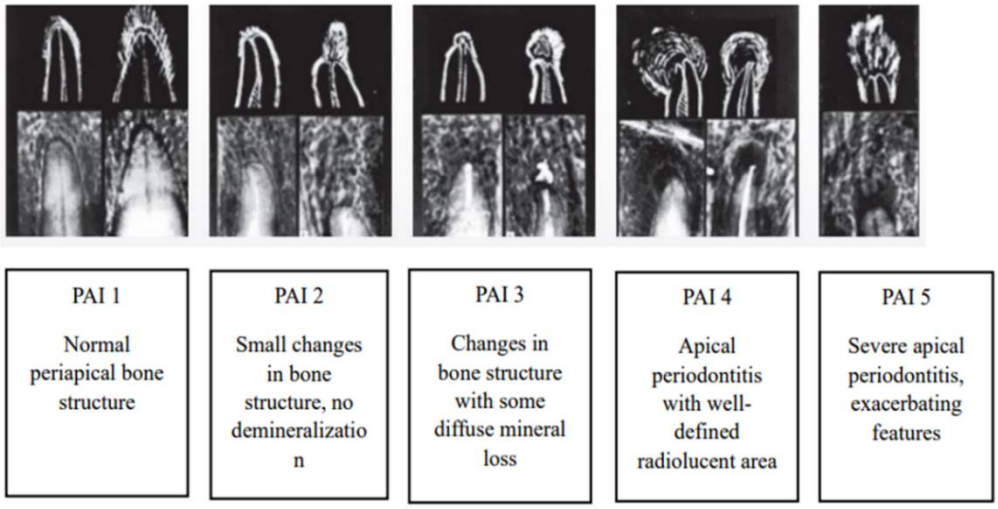


**Figure 1.** Reference radiographs, line-drawings and associated PAI scores (Orstavik et al., 1986)

#### 2.3.2. Survival analysis

For survival analysis, all periapical radiographs taken during the follow-up period were evaluated. Extractions due to endodontic failure, such as sinus tract recurrences, were classified as extractions. In contrast, extractions due to non-endodontic reasons, like strategic prosthetic reasons, were considered censored data. If an extraction was performed at a local clinic and the exact time of extraction could not be determined, the last follow-up visit was considered the extraction date.

## 2.4. Statistical analysis

All data were analyzed using IBM SPSS Statistics for Windows, version 27.0 (IBM Corp., Armonk, NY, USA). To assess the impact of the identified factors on the success rate, chi-square tests were employed. Additionally, multivariable logistic regression analysis was utilized to predict the likelihood of various success outcomes. Survival rates between groups and factors influencing survival were analyzed using Kaplan-Meier survival curves and the Cox proportional hazards model. All statistical tests were conducted at a 95% significance level ($p < 0.05$). The agreement between evaluators was measured using Cohen's weighted kappa statistics.

# 3. Results

## 3.1. Demographic data of the study

The demographic data distribution for this study is presented in Table 1 and 2. After the application of the inclusion and exclusion criteria outlined above, a total of 733 teeth were included, comprising 401 mandibular first molars and 332 mandibular second molars. For mandibular first molars, the average recall period was 84.5 months, with a range from 39 to 216 months. For mandibular second molars, the average recall period was 80.1 months, ranging from 6 to 202 months. The prevalence of C-shaped canals in mandibular second molars was 34.9%.

**Table 1.** The demographic data of the mandibular first molars

| | | Number of cases | Percentage |
|---|---|---|---|
| Age | 0-19 | 29 | 7.23 |
| | 20-39 | 124 | 31.0 |
| | 40-59 | 154 | 38.4 |
| | ≥60 | 94 | 23.4 |
| Gender | Male | 168 | 41.9 |
| | Female | 233 | 58.1 |
| Location | Left | 204 | 50.9 |
| | Right | 197 | 49.1 |
| Treatment | RCT | 284 | 70.8 |
| | Re-RCT | 117 | 29.2 |
| Total | | 401 | 100 |
| Average recall period | | 84.5 months | |

**Table 2.** The demographic data of the mandibular second molars

| | | Number of cases | Percentage |
|---|---|---|---|
| Age | 0-19 | 11 | 3.3 |
| | 20-39 | 109 | 32.8 |
| | 40-59 | 121 | 36.4 |
| | ≥60 | 91 | 27.4 |
| Gender | Male | 172 | 51.8 |
| | Female | 160 | 48.2 |
| Location | Left | 169 | 51.0 |
| | Right | 163 | 49.0 |
| Treatment | RCT | 258 | 77.7 |
| | Re-RCT | 74 | 22.3 |
| Canal Shape | C-shaped | 116 | 34.9 |
| | Non C-shaped | 216 | 65.1 |
| Total | | 332 | 100 |
| Average recall period | | 80.1 months | |

## 3.2. Evaluation of 4-year success rate for mandibular molars

The Cohen's kappa coefficient for agreement in radiographic assessment between the two reviewers was 0.835, indicating almost perfect agreement. Table 3 and 4 show 4-year success rate of root canal treatment in mandibular molars. The 4-year success rate of root canal treatment for mandibular first molars and mandibular second molars were 63.34% and 73.49%, respectively. The difference in success rates between the two groups was statistically significant. In mandibular second molars, the success rate for C-shaped canal teeth was 75.00%, while for non C-shaped canal teeth, it was 72.69%. There was no statistically significant difference between the two groups.

**Table 3**. 4-Year success rate of root canal treatment in mandibular molars

| | Success | Failure | Total | Success Rate(%) | p-value |
|---|---|---|---|---|---|
| Mn. 1st molar | 254 | 147 | 401 | 63.34 | |
| Mn. 2nd molar | 244 | 88 | 332 | 73.49 | |
| Total | 498 | 235 | 733 | | 0.03* |

**Table 4**. 4-Year success rate of root canal treatment in mandibular second molars

| | Success | Failure | Total | Success Rate(%) | p-value |
|---|---|---|---|---|---|
| C-shaped | 87 | 29 | 116 | 75.00 | |
| Non C-shaped | 157 | 59 | 216 | 72.69 | |
| Total | 244 | 88 | 332 | | 0.65 |

## 3.3. Factors affecting success rate

A multivariable logistic regression analysis was conducted to determine the factors influencing the success rate. The findings, presented in Table 5, indicate that only the tooth number showed a significant correlation with the success of root canal treatment.

**Table 5.** A multivariable logistic regression analysis of the success rate in mandibular molars

| | | B | p value | Exp (B) |
|---|---|---|---|---|
| Step 1 | Age | | 0.798 | |
| | | -0.041 | 0.912 | 0.960 |
| | | 0.020 | 0.956 | 1.020 |
| | | 0.169 | 0.652 | 1.185 |
| | Sex | -0.279 | 0.086 | 0.757 |
| | Location | -0.144 | 0.370 | 0.866 |
| | Tooth number | -0.495 | 0.003 * | 0.609 |
| | Constant | 0.307 | 0.599 | 1.359 |
| Step 5 | Tooth number | -0.473 | 0.003 * | 0.623 |
| | Constant | -0.074 | 0.760 | 0.929 |

## 3.4. Survival analysis

The survival rate of mandibular molars was calculated using Kaplan-Meier survival analysis and the log-rank test, and further analyzed with the Cox proportional hazards model. Figure 2 illustrates the Kaplan-Meier survival plot of mandibular molars, showing a statistically significant difference in survival rates, with mandibular first molars having lower survival rates compared to mandibular second molars. However, as shown in Figure 3, the survival plot of mandibular second molars indicates no significant difference between those with C-shaped canals and those with non C-shaped canals.

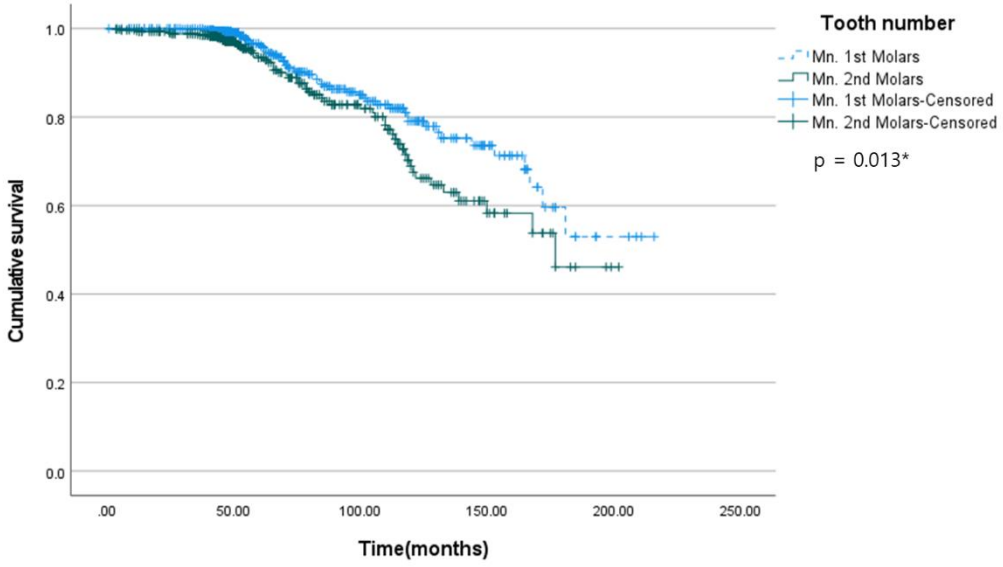


**Figure 2.** Kaplan-Meier survival plot for mandibular molars

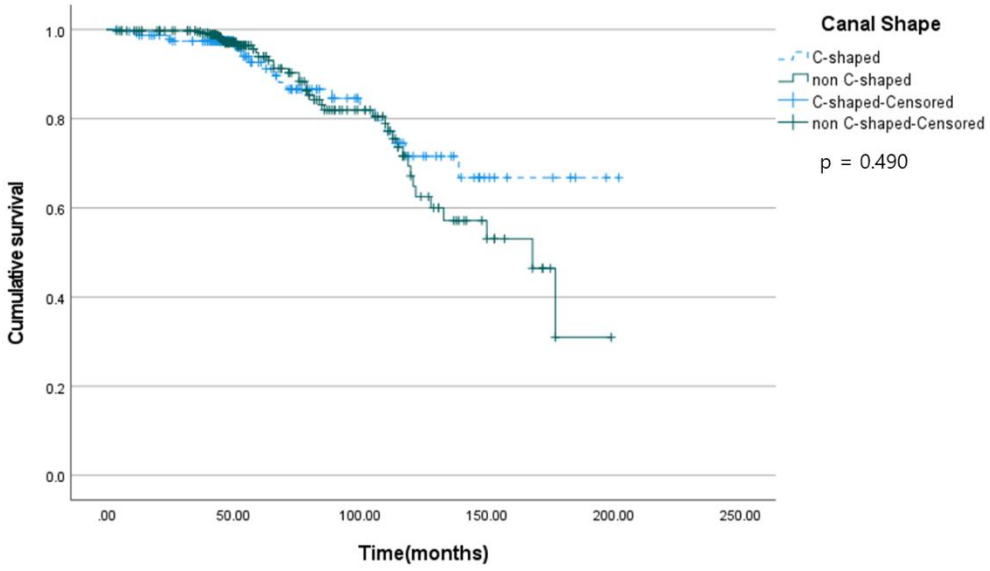


**Figure 3.** Kaplan-Meier survival plot for mandibular second molars

Table 6 presents the Cox regression analysis of survival rates in mandibular molars. In Step 4, age was a statistically significant factor, with each additional year reducing the survival rate by approximately 1.03 times. Sex also showed a significant effect, with females having a 1.66 times higher survival rate compared to males. Tooth number (mandibular first vs. second molars) showed a borderline trend toward significance, with mandibular second molars having approximately 1.40 times higher success rates compared to mandibular first molars.

Figure 4 illustrates the Cox regression-based survival curves for mandibular first and second molars. The survival curve for mandibular second molars shows a slightly lower success rate compared to mandibular first molars. However, this difference was not statistically significant ($p = 0.077$).

Table 7 summarizes the Cox regression analysis for survival outcomes of mandibular second molars. Age was a statistically significant factor, with each additional year slightly reducing the survival rate

by approximately 1.02 times. In contrast, sex, location, and canal shape (C-shaped vs. non C-shaped) were not significant predictors of survival.

**Table 6.** A Cox regression analysis of the survival rate in mandibular molars

| | | B | p value | Exp (B) |
|---|---|---|---|---|
| Step 1 | Age | 0.025 | 0.000* | 1.025 |
| | Sex | -0.510 | 0.008* | 0.600 |
| | Location | 0.043 | 0.822 | 1.044 |
| | Tooth number | 0.335 | 0.079 | 1.398 |
| Step 4 | Age | 0.025 | 0.000* | 1.025 |
| | Sex | -0.507 | 0.009* | 0.602 |
| | Tooth number | 0.337 | 0.077 | 1.401 |

**Table 7.** A Cox regression analysis of the survival rate in mandibular second molars

| | | B | p value | Exp (B) |
|---|---|---|---|---|
| Step 1 | Age | 0.019 | 0.025* | 1.019 |
| | Sex | -0.347 | 0.187 | 0.707 |
| | Location | 0.333 | 0.207 | 1.395 |
| | Canal Shape | 0.053 | 0.846 | 1.055 |
| Step 4 | Age | 0.021 | 0.012* | 1.021 |

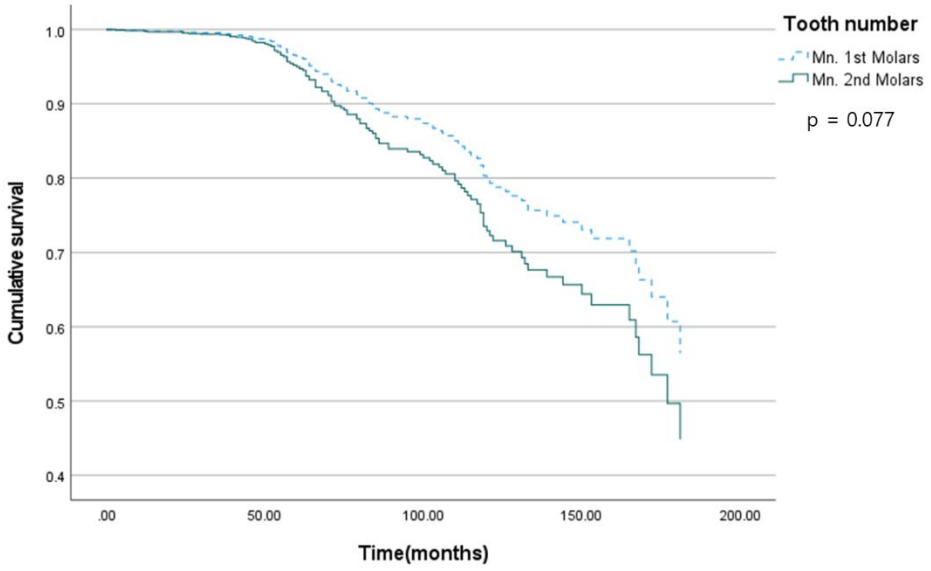


**Figure 4.** Survival analysis of mandibular molars using Cox regression models

# 4. Discussion

According to this study, significant factors influencing the long-term success rates of mandibular molars include tooth position. The presence of a C-shaped canal in mandibular second molars does not significantly impact the success rate. This observation challenges the conventional belief that C-shaped canals increase the complexity and likelihood of failure in root canal treatments.

The reduced success rate in mandibular first molars can be attributed to both their early eruption and complex anatomical structure. As the first permanent teeth to erupt, typically around the age of 6, mandibular first molars are exposed to oral health challenges for a prolonged period. This extended exposure increases their susceptibility to dental caries and periodontal disease(Pahel et al., 2017), which, over time, can lead to structural damage such as canal obliteration and bone loss(Jadhav & Mittal, 2024). Canal obliteration, characterized by partial or complete calcification of the root canal spaces, significantly complicates the process of locating, negotiating, and instrumenting canals during root canal therapy.

The anatomical complexity of mandibular first molars is another contributing factor to their lower success rate. While most mandibular first molars possess two roots, the incidence of a third root was found to be 13%(de Pablo et al., 2010). The prevalence is strongly correlated with the ethnicity of the studied population, being more common among Asians, Mongolians, and Eskimos. Notably, multiple studies focusing on the presence of a third root in Asian's population found the incidence to exceed 20%.(Song et al., 2009) Isthmus communications were found in an average of 54.8% of mesial roots and 20.2% of distal roots. Additionally, the incidence of a mesio-central or middle mesial canal was up to 14.8%. (Navarro et al., 2007) Therefore, mandibular first molars have a sufficiently complex anatomical structure comparable to mandibular second molars, and the

possibility of missing canals may contribute to the lower success rate of root canal treatment.

In this study, there was no difference in the success rate of root canal treatment between C-shaped and non-C-shaped canals in mandibular second molars. This finding is consistent with previous research by Ahn et al.(Ahn et al., 2016), indicating that even in long-term follow-ups, C-shaped canals do not have a lower success rate compared to teeth with non C-shaped canals. This is thought to be due to advancements in irrigation systems and rotary instruments, which allow for effective disinfection of structures such as isthmus and fins while minimizing the removal of tooth structure.

Integrating the findings from the Kaplan-Meier survival analysis and the Cox regression model, this study identifies age and sex as the key factors significantly influencing mandibular molar survival. In this study, males exhibited lower survival rates of mandibular molars after root canal treatment compared to females, a result consistent with previous findings. In 2019, Kwak et al. found that the 5-year survival rate was lower in males compared to females(Kwak et al., 2019). This may be attributed to various factors, including differences in occlusal force leading to a higher prevalence of vertical root fractures (VRF)(Koc et al., 2010), as well as disparities in access to dental care.

In this study, age was found to significantly influence tooth survival after root canal treatment, with a hazard ratio ranging from 1.019 to 1.03 depending on the tooth location. This finding closely corresponds to the hazard ratio of 1.02 reported by Ng et al. in 2011, indicating similarity in the impact of age on root canal treatment outcomes between the two studies(Ng et al., 2011a).

In mandibular second molars, canal shape showed no significant influence on survival rates between C-shaped and non C-shaped canals. This aligns with the previously mentioned finding that endodontic success rates between C-shaped and non C-shaped canals also showed no significant difference.

Although the Kaplan-Meier analysis indicated a statistically significant difference in survival rates between mandibular first and second molars, this difference was not supported by the Cox regression model. This discrepancy is thought to be due to an insufficient sample size or interactions between variables, highlighting the need for further research with larger sample sizes to better evaluate its potential impact.

Despite the lower success rate of root canal treatment in mandibular first molars compared to second molars, survival analysis showed favorable results. This is likely due to the diverse root types providing periodontal support and the advantageous position in the anterior part of the dental arch, which facilitates instrument access and makes secondary interventions such as apicoectomy or hemisection more feasible. This suggests that the success rate of mandibular first molars is more likely underestimated compared to their actual clinical outcomes.

This study is significant in that it compares the long-term success and survival rates of mandibular molars. The main limitation of this study is that it only includes patient factors affecting the success rate. If intraoperative and postoperative factors were included in the regression analysis, factors other than the type of tooth might have been identified as influencing the success rate.

# 5. Conclusion

This study evaluated the long-term success and survival rates of nonsurgical root canal treatments in mandibular molars from 2005 to 2015. A total of 733 teeth were included, with 401 mandibular first molars and 332 mandibular second molars. The four-year success rate was 63.34% for mandibular first molars and 73.49% for mandibular second molars, with a statistically significant difference between the two groups. However, no significant difference was found between C-shaped and non C-shaped canals in mandibular second molars. Mandibular second molars trend toward better survival than first molars, but the difference is not statistically significant. Canal shape (C-shaped vs. non C-shaped) does not affect survival rates, with similar outcomes observed across groups.

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Abstract in Korean

# 하악 제1대구치와 제2대구치의 근관치료의 장기 결과에 대한 후향적 비교 연구

비수술적 근관치료의 성공률 차이는 치아의 악궁 내 위치와 해부학적 변이에 의해 영향을 받을 수 있다. C형 근관은 근관 치료를 복잡하게 만들어 성공률을 낮추는 주요 요인으로 간주되어 왔다. 이에 본 연구는 하악 제1대구치와 제2대구치의 근관치료에 대한 장기 성공률과 생존율을 비교하고, 치열 내 위치가 성공률에 미치는 영향을 분석하며, 하악 제2대구치의 C형 근관과 비 C형 근관을 비교하여 해부학적 변이의 영향을 평가하고자 한다. 2005년부터 2015년까지 하악 대구치에 비수술적 근관치료를 받은 환자의 임상 데이터베이스를 검토하였다. 각 환자의 임상 및 방사선 기록을 검토했으며, 두 명의 검사자가 Periapical index scoring system을 사용해 치근단 방사선을 평가하고 평가자간 일치도를 분석했다. 다양한 요인이 성공률에 미치는 영향을 분석하기 위해 카이제곱 검정을 사용했으며, 다변량 로지스틱 회귀분석으로 다양한 성공 결과의 가능성을 예측했다. Kaplan-Meier 통계, 로그-랭크 검정, 그리고 Cox 비례 위험 모델을 이용해 그룹 간 생존율을 비교했다.

총 733개의 치아가 성공률 분석에 포함되었으며, 이 중 하악 제1대구치는 401개, 제2대구치는 332개였다. 4년 성공률은 하악 제1대구치가 63.34%, 제2대구치가 73.49%로, 두 그룹 간 통계적으로 유의미한 차이를 보였다. 그러나 하악 제2대구치

의 C형 근관과 비 C형 근관 간에는 유의미한 차이가 없었다. 다변량 로지스틱 회귀 분석 결과, 치아의 악궁 내 위치(치아번호)만이 성공률과 유의미하게 상관관계가 있는 것으로 나타났다. Kaplan-Meier 생존 분석과 로그-랭크 검정에서는 하악 제1대구치가 제2대구치에 비해 통계적으로 유의미하게 높은 생존률을 보였으나, 하악 제2대구치의 C형 근관과 비 C형 근관 간에는 유의미한 차이가 없었다. Cox 비례 위험 분석에서는 하악 제2대구치가 제1대구치보다 근관 치료 후 생존율이 낮은 것으로 나타났으나, 통계적으로 유의미하지는 않았다.

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**핵심되는 말** : 비수술적 근관 치료, 재근관치료, 하악 대구치, C형 근관, 임상결과, 장기간 연구