



Original Article

Comparison of the implementation of extra root canal treatment before and after fee schedule change in the Taiwan National Health Insurance System



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Abstract *Background/purpose:* Endodontic treatment success depends on treatment of all root canals, but the implementation status is affected by various factors. We examined whether the fee payment change affected the extra root canal endodontic treatment (EXRCT) in adult teeth in the National Health Insurance (NHI) system of Taiwan since 2008. The effect of hospital level, sex, and age on EXRCT was also examined.

Materials and methods: Two longitudinal health insurance databases for 2005 and 2010 were used. Excluding third molars and endodontic retreatment, the EXRCT rate in permanent dentition were compared for different tooth positions, hospital levels, sex and age between 2005 and 2010.

Results: In total, 80,995 teeth in 2005 and 76,018 in 2010 underwent root canal filling. The rate of EXRCT increased markedly from 2005 to 2010, particularly for the upper first molar (1.84% to 3.18%), lower first premolar (3.45% to 4.58%), lower first molar (12.4% to 18%), and lower second molar (0.95% to 1.87%). The difference between 2005 and 2010 remained statistically significant after adjustment for hospital level, sex, and age. The lower second molar had the highest adjusted odds ratio for the difference between 2005 and 2010 (1.99; CI: 1.49–2.66),

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followed by the upper first molar (1.91; CI: 1.55–2.35), lower first molar (1.60; CI: 1.47–1.75), and lower first premolar (1.38; CI: 1.11–1.72).

Conclusion: The payment change of Taiwan NHI seems to encourage the use of EXRCT in molars. Hospital level, sex, and age also affected the rate of EXRCT.

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Introduction

The success of endodontic treatment is dependent on the complete examination, cleaning, shaping, and obturation of all root canals present in the affected tooth.¹ Any undetected root canal may pose a major risk for endodontic failure.² Teeth with a missing canal were reported to be 4.38 times more likely to be associated with an apical lesion.³ In the USA, the incidence of missing canals was shown to be 23.04% and 42% in two previous studies.^{3,4} The incidence of missing canals was found to be highest in the upper first molar and lowest in the upper premolars.³ Previous in vivo and in vitro studies have shown that the incidence of a second mesiobuccal canal (MB2) in the maxillary first molar ranges from 56.9% to 96.0%.⁵ The detection of an MB2 canal in the maxillary second molar varied between 29% and 100% in vitro studies and between 19.7% and 51.1% in in vivo studies.⁶ Understanding each tooth's anatomy facilitates detection of canals by the endodontist.⁴ Other factors, such as access cavity design, retreatment, and magnification were also found to affect the number of canals discovered.⁷

When considering predictors related to the detection of root canals, the payment system may also affect the results. In Taiwan, endodontic treatment is covered by the National Health Insurance (NHI). In 2008, the NHI started to reimburse extra root canal endodontic treatment (EXRCT) for four-canal and five-canal systems. The purpose of the present study was to examine whether the fee payment change in the National Health Insurance affected the rate of EXRCT in adult teeth. The effect of age, sex, and hospital level on EXRCT was also examined.

Material and methods

Data source

The primary data source of this study comprised the two longitudinal health insurance databases of 2005 (LHID2005) and 2010 (LHID2010) of the Taiwan NHI. In 1995, Taiwan launched a compulsory single-payer NHI system, which covered 99.6% of the population as of 2014.⁸ For the LHID2005 and LHID2010, two separate cohorts of 1,000,000 individuals were randomly sampled from all beneficiaries of the NHI program in 2005 and in 2010, respectively. All data on registration, outpatient claims, and inpatient claims for these two samples of one million individuals—from their registration in the NHI program until 2013—were included in the LHID2005 and LHID2010. There were no significant

differences in sex distribution between patients in the LHID and those in the original data.

This study was approved by the Institutional Review Board of Chang Gung Memorial Hospital, Taiwan (IRB). The need for informed patient consent was waived, as all data were completely anonymized.

Ascertainment of root canal treatment

We only used the data of 2005 in the LHID2005 and 2010 in LHID2010 because the data in these two years are representative of the population in 2005 and 2010, respectively. Next, we excluded individuals who had the same anonymized ID number on the LHID2010 as the number on the LHID2005 ($n = 74,926$, 7.49%), to avoid double-counting of patients in the two LHIDs. In this study, the study unit was permanent teeth that required root canal treatment, rather than patients.

Extra canals were simply defined as more than one canal for anterior teeth (#11 #21, #12 #22, #13 #23, #31 #41, #32 #42, #33 #43) and lower premolars (#34 #44, #35 #45), more than two canals for upper premolars (#14 #24, #15 #25), and more than three canals for molars (#16 #26, #17 #27, #36 #46, #37 #47). The treatment codes in 2005 were 90001C for 1-canal system; 90002C for 2-canal system; 90003C for 3-or-more canal system, 90092C for extra-canal system. In 2008, the NHI started to reimburse four-root canal endodontic treatment (90019C) and five-root canal treatment (90020C). The treatment codes in 2010 were 90001C for a one-canal system; 90002C for a two-canal system; 90003C for a three-canal system; 90019C for a four-canal system; 90020C for a five-or-more canal system, 90092C for extra-canal system. Note that the retreatment cases (treatment code 90094C) and third molars (#18 #28, #38 #48) were excluded.

Covariates

Other than the two time-points (calendar years 2005, 2010), tooth position, hospital level, sex and age were potential factors for EXRCT. Hospital was grouped into four levels (medical center, regional hospital, local hospital, and dental clinic). Age in years was grouped into eight categories (6–19, 20–29, 30–39, 40–49, 50–59, 60–69, 70–79, and ≥ 80).

Statistical analysis

To explore which factors affected EXRCT, generalized estimating equation (GEE) with an exchangeable

covariance structure and logit link was made to account for non-independence of teeth from the same individual (Fig. 1). Interaction of calendar years with tooth position, hospital level, sex and age, was examined to determine whether the change in EXRCT in the two calendar years were consistent for tooth position, hospital level, sex, and age group, respectively. When the data was stratified by tooth position, logistic regression was made to examine which factors affected EXRCT. Adjusted odds ratios (ORs) with 95% confidence intervals (CIs) of EXRCT were shown to reflect the risk of EXRCT in 2010 as compared to that in 2005, after adjustment for hospital level, sex, and age group. The significant level of this study (α) was 0.05. The Bonferroni correction was made to compensate an increase due to testing each individual hypothesis at a significance level of α/m . The m was 4 for Fig. 1 (a, b, c, d) and m was also 4 for Table 2 (#16 #26, #34 #44, #36 #46, #37 #47).

Results

Table 1 shows the proportion of root canal treatment for the two years for each tooth position, hospital level, sex, and age. In 2005, 17,184 (21.21%) incisors, 7535 (9.4%) canines, 25,653 (31.67%) premolars, and 30,623 (37.8%) molars received root canal treatment. In 2010, 15,140 (19.92%) incisors, 7234 (9.51%) canines, 24,744 (32.55%) premolars, and 28,900 (38.02%) molars underwent root canal treatment. Most root canal treatment was performed in dental clinics (95.4%). The number of female patients (57.1%) was

slightly higher than that of male patients (42.9%). The mean patient age was 42.7 years in 2005 and 45.3 years in 2010 (Table 1).

Fig. 1 displays the proportion of EXRCT among those teeth which were received root canal endodontic treatment for the two years for each tooth position (Fig. 1a), hospital level (Fig. 1b), sex (Fig. 1c), and age (Fig. 1d). The lower first molar accounted for the highest proportion of teeth receiving EXRCT, followed by the lower first premolar, upper first molar, lower lateral incisor, and lower second molar. Other teeth receiving EXRCT accounted for less than 1% in each teeth category. Most EXRCT were performed in medical centers, followed by regional hospitals, local hospitals, and dental clinics. More men than women underwent EXRCT. The rate of EXRCT decreased with age (Fig. 1d). Only the interaction between year (2005 vs. 2010) and tooth position was statistically significant ($p < 0.0001$) (Fig. 1a), indicating a difference in the proportion of EXRCT between the two years that varied with tooth position. Hence, we compared the proportion of EXRCT between the two years for each tooth position. The use of EXRCT in 2010 was significantly higher than that in 2005 for the upper first molar ($p < 0.0001$), lower first premolar ($p = 0.0078$), lower first molar ($p < 0.0001$), and lower second molar ($p < 0.0001$).

Among these tooth positions, we investigated whether hospital level, sex, and age affected the proportion of EXRCT implemented in the two calendar years (Table 2). Logistic regression analysis revealed that the calendar year remained a statistically significant factor after adjusting for

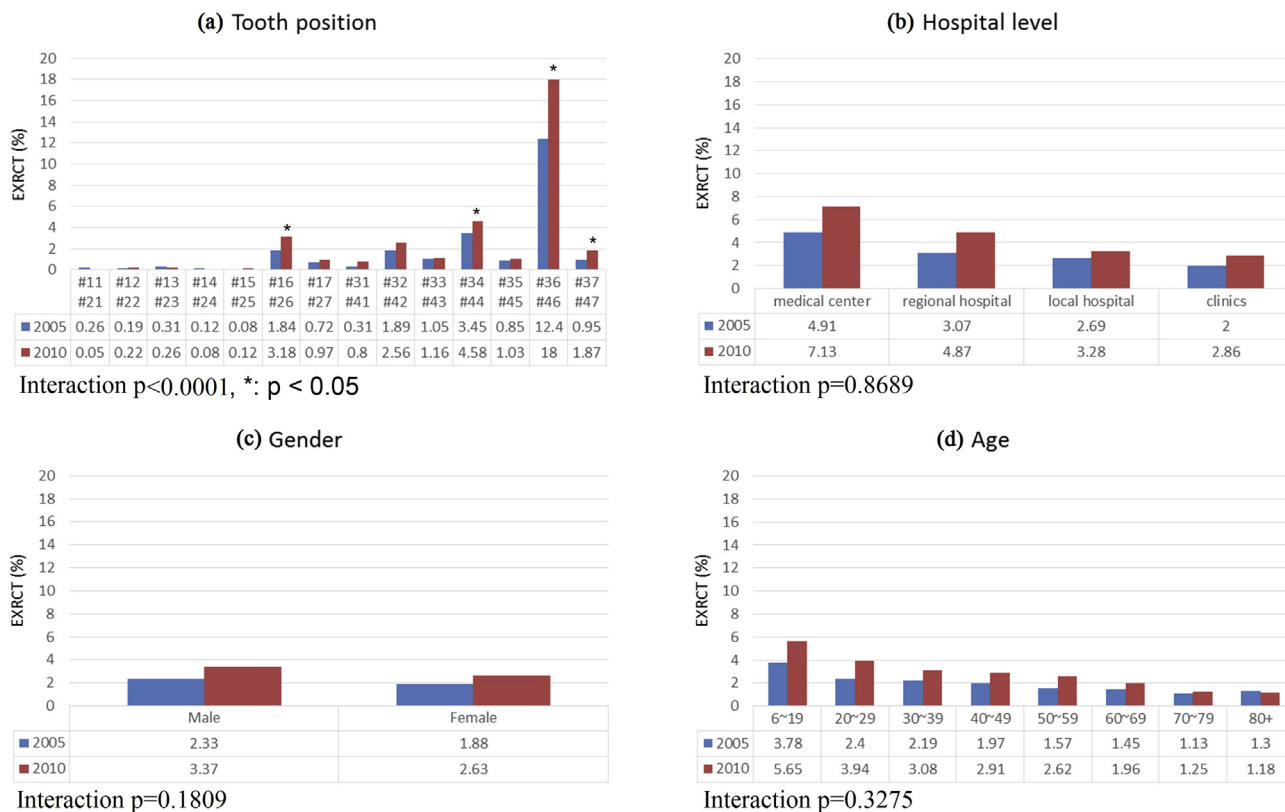


Figure 1 Percentage of extra root canal endodontic treatment (EXRCT) among those teeth which were received root canal endodontic treatment in 2005 and 2010, Taiwan. (a) By tooth position, (b) by hospital level, (c) by sex, (d) by age.

Table 1 Teeth received root canal endodontic treatment in 2005 and 2010, Taiwan.

	Total (n = 157,013)	2005 (n = 80,995)	2010 (n = 76,018)
Tooth position			
Upper central incisor (#11#21)	13,795 (8.79%)	7403 (9.14%)	6392 (8.41%)
Upper lateral incisor (#12#22)	11,607 (7.39%)	6238 (7.70%)	5369 (7.06%)
Upper canine (#13#23)	9343 (5.95%)	4780 (5.90%)	4563 (6.00%)
Upper first premolar (#14#24)	12,654 (8.06%)	6446 (7.96%)	6208 (8.17%)
Upper second premolar (#15#25)	15,671 (9.98%)	7924 (9.78%)	7747 (10.19%)
Upper first molar (#16#26)	15,917 (10.14%)	8264 (10.20%)	7653 (10.07%)
Upper second molar (#17#27)	12,525 (7.97%)	6248 (7.71%)	6277 (8.26%)
Lower central incisor (#31#41)	3259 (2.08%)	1636 (2.02%)	1623 (2.14%)
Lower lateral incisor (#32#42)	3663 (2.33%)	1907 (2.35%)	1756 (2.31%)
Lower canine (#33#43)	5426 (3.46%)	2755 (3.40%)	2671 (3.51%)
Lower first premolar (#34#44)	8515 (5.42%)	4346 (5.37%)	4169 (5.48%)
Lower second premolar (#35#45)	13,557 (8.63%)	6937 (8.56%)	6620 (8.71%)
Lower first molar (#36#46)	16,525 (10.52%)	8656 (10.69%)	7869 (10.35%)
Lower second molar (#37#47)	14,556 (9.27%)	7455 (9.20%)	7101 (9.34%)
Hospital level			
Medical center	1895 (1.21%)	1039 (1.28%)	856 (1.13%)
Regional hospital	3214 (2.05%)	1696 (2.09%)	1518 (2.00%)
Local hospital	2087 (1.33%)	1080 (1.33%)	1007 (1.32%)
Clinics	149,817 (95.42%)	77,180 (95.29%)	72,637 (95.55%)
Sex			
Male	67,338 (42.89%)	34,436 (42.52%)	32,902 (43.28%)
Female	89,675 (57.11%)	46,559 (57.48%)	43,116 (56.72%)
Age (years)			
6–19	13,233 (8.43%)	7838 (9.68%)	5395 (7.10%)
20–29	24,862 (15.83%)	13,974 (17.25%)	10,888 (14.32%)
30–39	26,596 (16.94%)	13,676 (16.88%)	12,920 (17.00%)
40–49	31,441 (20.02%)	16,677 (20.59%)	31,441 (20.02%)
50–59	29,884 (19.03%)	14,133 (17.45%)	29,884 (19.03%)
60–69	18,142 (11.55%)	8742 (10.79%)	18,142 (11.55%)
70–79	10,332 (6.58%)	4954 (6.12%)	5378 (7.07%)
80+	2523 (1.61%)	1001 (1.24%)	1522 (2.00%)
Mean ± SD	43.95 ± 17.27	42.71 ± 17.24	45.28 ± 17.20

hospital level, sex, and age. The lower second molar had the highest adjusted OR for the calendar year (1.99, 95% CI: 1.49–2.66), followed by upper first molar (1.91, 95% CI: 1.55–2.35), lower first molar (1.60, 95% CI: 1.47–1.75), and lower first premolar (1.38, 95% CI: 1.11–1.72). The policy change, involving an increased fee for four-canal and five-canal systems, seems to encourage the use of EXRCT in the molars (Table 2).

Other than calendar year, hospital level, sex, and age affected the practice rate of EXRCT. Medical centers, regional hospitals, and local hospitals were more likely to perform EXRCT when compared with dental clinics. Compared with women, men tended to have higher ORs to have EXRCT. Older patients were less likely to receive EXRCT than those aged 6–19 years (Table 2).

Discussion

In the present study, tooth position was the most important factor associated with EXRCT in Taiwan. The highest percentage of extra canals was detected in the lower first molar, followed by the lower first premolar and the upper

first molar. Furthermore, extra canals were seldom detected in the upper anterior teeth and upper premolars. These results were consistent with the anatomic differences between these teeth. Maxillary anterior teeth mostly have one canal.⁹ The maxillary first premolars typically have two roots and two root canals.¹⁰ The incidence of extra canals was reported to be 0–6% in maxillary first premolars and 0–2% in maxillary second premolars.¹¹ The maxillary molar usually has three roots.¹⁰ The incidence of a second mesiobuccal (MB2) canal in maxillary first molars varied between 56.9% and 96% in previous studies.⁵ The incidence of an MB2 canal in the maxillary second molar varied between 29% and 100% in in vitro studies, and between 19.7% and 51.1% in in vivo studies.⁶ In mandibular teeth, the prevalence of two root canals in the lateral incisors was higher than that in the central incisors and the canines.¹² The incidence of mandibular first premolars with more than one canal has been reported to range from 11.53% to 46% and the incidence of an extra canal in the mandibular second premolar was reported to be 9%.¹³ A study in 2009 found that the occurrence of four canals in the mandibular first molar in a Taiwanese population was higher, and approached almost one-half (46%) of the teeth.¹⁴

Table 2 Multivariate analysis of extra root canal endodontic treatment (EXRCT) by tooth position in 2005 and 2010, Taiwan.

	Odds ratio (95% CI); p value			
	Upper first molar (#16#26)	Lower first premolar (#34#44)	Lower first molar (#36#46)	Lower second molar (#37#47)
Year (ref: 2005)				
2010	1.91 (1.55–2.35) p < 0.0001	1.38 (1.11–1.72) p = 0.0044	1.60 (1.47–1.75) p < 0.0001	1.99 (1.49–2.66) p < 0.0001
Hospital level (ref: clinics)				
Medical center	9.27 (5.90–14.56) p < 0.0001	3.15 (1.66–6.01) p = 0.0005	2.85 (2.03–3.98) p < 0.0001	1.09 (0.27–4.44) p = 0.9044
Regional hospital	3.19 (1.89–5.40) p < 0.0001	2.03 (1.11–3.71) p = 0.0213	1.56 (1.18–2.07) p = 0.0017	2.79 (1.41–5.52) p = 0.0033
Local hospital	2.30 (1.11–4.75) p = 0.0244	2.04 (0.98–4.25) p = 0.0558	1.27 (0.88–1.83) p = 0.1996	1.39 (0.44–4.39) p = 0.5778
Sex (ref: Female)				
Male	1.74 (1.42–2.13) p < 0.0001	1.90 (1.53–2.37) p < 0.0001	1.10 (1.01–1.20) p = 0.0282	1.45 (1.10–1.91) p = 0.0092
Age (ref: 6–19)				
20–29	1.17 (0.85–1.62) p = 0.3367	0.50 (0.24–1.02) p = 0.0554	0.95 (0.83–1.09) p = 0.4240	–
30–39	0.75 (0.54–1.06) p = 0.1029	0.70 (0.38–1.32) p = 0.2697	0.87 (0.75–1.00) p = 0.0492	–
40–49	0.57 (0.41–0.82) p = 0.0017	0.52 (0.28–0.97) p = 0.0396	0.74 (0.65–0.86) p < 0.0001	–
50–59	0.36 (0.25–0.54) p < 0.0001	0.40 (0.22–0.75) p = 0.0039	0.73 (0.63–0.85) p < 0.0001	–
60–69	0.23 (0.13–0.41) p < 0.0001	0.29 (0.15–0.57) p = 0.0003	0.64 (0.53–0.78) p < 0.0001	–
70–79	0.25 (0.11–0.56) p = 0.0007	0.28 (0.14–0.57) p = 0.0004	0.39 (0.28–0.53) p < 0.0001	–
80+	0.15 (0.02–1.11) p = 0.0633	0.23 (0.09–0.62) p = 0.0039	0.53 (0.30–0.93) p = 0.0274	–

The percentages of EXRCT applied in upper molars and lower teeth were clearly increased in 2010 over that in 2005, but this difference only reached statistical significance for upper first molars, lower first premolars, lower first molars, and lower second molars. Further analysis of factors significantly influencing this increase in EXRCT in these tooth positions has revealed that the year is the most important factor for mandibular first molars and second molars, even though hospital level, age, and sex also contribute. The overall increase in detecting extra canals from 2005 to 2010 may be associated with the advance in knowledge, armamentarium and techniques, and the growth of doctors and specialists with endodontic training.¹⁵ Alternatively, the significant increase in molars may involve the payment changes in 2008. In 2005, only one, two, and three canals were payment items for root canal fillings. If a tooth had four or more canals, it could be declared as a three-canal item, and the extra-canal item added. In 2010, the payment items for root canal filling were changed to specify one, two, three, four, and five canals. The endodontic treatment fee for four canals and five canals were raised by 20–25% in 2010 as compared with the fee in 2005. The payment change for four-canal and five-canal systems seems to encourage the use of EXRCT in molars.

The hospital level was also associated with EXRCT in Taiwan. Hospitals are divided into four categories: medical centers, regional hospitals, local hospitals, and dental clinics. The highest percentage of EXRCT was provided in medical centers, followed by regional hospitals, local community hospitals, and dental clinics. This may be due to the greater resources and well-trained endodontic specialists in medical centers. Prevention of missed anatomy is associated with good knowledge about diagnostic imaging, proper pulp chamber opening, use of the operating microscope, and ultrasonics.¹⁶ However, most endodontic treatments were performed at dental clinics, where most dentists have practiced. The promotion of post-graduate education in dental clinics is important to increase the overall quality of endodontic treatment.

In the present study, the percentage of EXRCT application decreased with age. This may be due to the reduction in active maximum mouth opening with age in adults.¹⁷ It is more difficult for a dentist to perform dental procedures when the mouth opening is reduced, and particularly if endodontic therapy of molars is required.¹⁸ Another reason is the increased canal calcification and dentin deposition with age.¹⁹ Previous laboratory studies have shown that the incidence of MB2 canals in maxillary first molars varies according to age; they were found in 80% of patients in their

twenties, but in 50% in their sixties. Therefore, a greater awareness about the changes that occur with age and auxiliary tools are needed during endodontic treatment in older individuals.¹⁹

In the present study, sex was also a factor associated with EXRCT. More men than women underwent EXRCT. This may be because men have a greater active maximum mouth opening value than women,¹⁷ which makes dental therapy easier in the posterior area, by providing appropriate access and good vision during endodontic treatment.

To achieve successful root canal therapy, it is important to avoid missing root canals; this is influenced by many factors. The policy change involving an increased fee for treatment of four-canal and five-canal systems seems to have encouraged detection of additional canals in molars. Other than calendar year, hospital level, sex, and age also affected the rate of EXRCT implementation. Awareness of these factors may be helpful to increase the quality of root canal therapy in Taiwan.

Conflicts of interest

The authors have no conflicts of interest relevant to this article.

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The funder had no role in the design and conduct of the study; collection, management, analysis, and interpretation of the data; preparation, review, or approval of the manuscript; and decision to submit the manuscript for publication.

Disclaimer

The interpretation and conclusions contained herein do not represent positions of the Administration of National Health Insurance, Taiwan, or the National Health Research Institutes, Taiwan.

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