

Five-year Follow-up Study of Tooth Extraction After Nonsurgical Endodontic Treatment in a Large Population in Taiwan

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Background/Purpose: Nonsurgical retreatment, apical surgery and tooth extraction are three major untoward events following nonsurgical root canal treatment (NSRCT). The purpose of this study was to assess untoward events and total tooth extraction after NSRCT in a large population of dental patients in Taiwan.

Methods: A total of 1,588,217 teeth treated with NSRCT in Taiwan in 2000 were analyzed for the first untoward event and total tooth extraction over a 5-year follow-up period.

Results: The first untoward event occurred in 192,488 (12.1%) teeth within the first 5 years post-treatment. Nonsurgical retreatment was performed on 69,273 (36.0%) of these teeth, 4741 (2.5%) received apical surgery, and 118,474 (61.5%) were extracted. In addition, 1,463,312 (92.1%) teeth treated with NSRCT were retained in the oral cavity, and 124,905 (7.9%), including 24,499 (19.6%) anterior teeth, 33,356 (26.7%) premolars, and 67,050 (53.7%) molars were extracted within the 5 years of follow-up. Of these 124,905 teeth, 5869 (4.7%) were extracted after nonsurgical retreatment, 562 (0.4%) after apical surgery, and 118,474 (94.9%) after the first untoward events. There were significantly more molars (54.5% vs. 43.3%) and significantly fewer anterior teeth (19.0% vs. 27.5%) extracted in private clinics than in hospitals ($p < 0.001$). The overall tooth extraction rate was significantly greater in hospitals (10.0%) than in private clinics (7.7%, $p < 0.001$). However, tooth extraction procedures were almost evenly distributed over the 5-year follow-up period, with the annual incidence being close to 20%. The overall mean tooth extraction time was significantly greater in private clinics (2.52 ± 1.43 years) than in hospitals (2.29 ± 1.50 years, $p < 0.001$).

Conclusion: We conclude that tooth extraction (61.5%) is the most common of the three untoward events, and approximately 95% of tooth extractions are performed at the time of the first untoward event. NSRCT is still a valuable dental procedure in Taiwan because of the high rate (92.1%) of tooth retention after 5 years of follow-up. [*J Formos Med Assoc* 2008;107(9):686–692]

Key Words: general population, root canal treatment, tooth extraction, tooth retention, untoward events

Endodontic treatment outcome can be assessed by case-control or follow-up epidemiologic studies. Case-control studies evaluate a relatively small number of endodontic treatment and control

cases. The criteria used for assessing success and failure may be different, therefore, endodontic treatment outcomes vary considerably between studies.¹ Follow-up epidemiologic studies examine

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a very large number of endodontically-treated patients in the general population. There are three examples of this type of study, which use an alternative approach to evaluate cases of nonsurgical root canal treatment (NSRCT) from the database of a nationwide health insurance organization.²⁻⁴ Epidemiologic studies assess a large number of endodontic treatments performed by dentists and endodontists, and their success rate may represent outcomes in the general population.²⁻⁴

Epidemiological radiographic surveys have reported a relatively lower frequency of high-quality root canal filling ranging from 14% to 65%.⁵ Our previous study evaluated the technical quality of root canal filling in 1085 cases treated with NSRCT, randomly selected from a large representative sample of the Taiwanese population, and found that only 30.3% of the teeth had received good-quality endodontic work.⁶

In Taiwan, the national health care plan was implemented in March 1995. This plan covers nearly all medical treatments and a portion of dental treatments, including surgical and nonsurgical endodontic procedures. The National Health Insurance (NHI) is managed by the Bureau of NHI (BNHI) which insures approximately 21 million individuals from a total population of 22 million. Providers have to make a claim for each treatment to the BNHI, therefore, a large computerized medical and dental database for each insured individual has been kept since March 1995. Access to BNHI's invaluable national data set makes it possible to study the first untoward events, including nonsurgical retreatment, apical surgery and tooth extraction, as well as tooth retention rate following NSRCT.

Two large epidemiologic studies using a long follow-up period have found very high tooth retention rates (94–97%) among a large number of NSRCT cases collected from an insurance company database.^{2,3} These results motivated our group to study the first untoward events and tooth retention rate over a 5-year follow-up period for 1,557,547 teeth treated with NSRCT in Taiwan in 1998. We found that the first untoward events occurred in 159,680 (10.3%) of these teeth during the 5-year

follow-up period. Moreover, a high 5-year tooth retention rate of 92.9% was observed.⁴ Here, we have further assessed the first untoward events and tooth retention rate over a 5-year follow-up period for 1,588,217 teeth that were treated with NSRCT in 2000. We compared the types of teeth extracted between hospitals and private clinics. Tooth extraction rates and mean extraction times were compared between six different regions of Taiwan, and between hospitals and private clinics in six different regions. In addition, the distribution of total tooth extraction cases in each of the five follow-up periods was studied and compared between six different regions of Taiwan.

Methods

We analyzed the initial NSRCT cases completed in 2000 from a pool of 21 million individuals insured by the NHI plan since March 1995. Details of 1,588,217 NSRCT procedures claimed in 2000 were collected by searching the database for the specific BNHI procedure codes, 90001C, 90002C and 90003C, which represent NSRCT performed in teeth with one, two, or three or more root canals, respectively. These 1,588,217 NSRCT procedures were principally performed by dentists and endodontists, and occasionally by other dental specialists.

The following information was also collected for each NSRCT procedure: tooth identification number, date of completion of endodontic procedure, and patient age. To ensure personal privacy, patient data, including identification number, gender and medical records, were not released by the BNHI. Each NSRCT tooth was followed for a continuous period of 5 years from the completion date of the endodontic procedure in 2000. A maximum of 25 related subsequent treatment codes and dates were collected. Of particular interest was evaluation of the first and last procedures, including untoward events, defined as nonsurgical retreatment, apical surgery and tooth extraction, in two prior epidemiological studies,^{2,3} for each tooth within the 5-year follow-up period.

The occurrence of untoward events was analyzed by searching the database for the BNHI procedure codes, 90001C, 90002C, 90003C, 90015C, 92030C, 92031C, 92032C, 90010C, 92013C and 92014C. The BNHI does not provide codes for nonsurgical retreatment. Therefore, a second appearance of the codes 90001C, 90002C and 90003C for the same tooth represented nonsurgical retreatment for a tooth with one, two, or three or more root canals, respectively. Procedure 90015C, for root canal enlargement and debridement, also belongs to the nonsurgical retreatment category. Procedures 92030C, 92031C and 92032C are the codes for apicoectomy in maxillary and mandibular anterior teeth, premolars and molars, respectively; and 90010C is the code for root-end filling. The item for apical surgery included both apicoectomy (92030C, 92031C, 92032C) and root-end filling (90010C). The BNHI codes for simple and complicated tooth extraction were 92013C and 92014C, respectively.

The first subsequent procedure for each NSRCT tooth was analyzed to disclose whether any untoward event occurred after the completion of NSRCT. In addition, the total number and incidence of each untoward event for all NSRCT teeth were calculated. The last related procedure for each NSRCT tooth was used to calculate how many teeth were extracted, and in turn, to determine the percentage of teeth retained after completion of the full 5-year follow-up period. Patient outcome criteria were applied blindly because the dentists submitting claims were not aware that the data would be used for future endodontic outcome analysis. At the end of the follow-up period in 2005, about 99% of the patients remained in the same NHI plan, which indicated very modest losses from the patient pool.

The number of extracted anterior teeth, premolars and molars were counted and compared between hospitals and private clinics using the χ^2 test. Tooth extraction rates were compared between six different regions (Taipei, north, central, south, Kaoping and east regions) of Taiwan, and between hospitals and private clinics in each of the six regions of Taiwan, using the χ^2 test.

Distribution of total tooth extractions in each of the 5 follow-up years in the six different regions of Taiwan was analyzed. Finally, the mean tooth extraction times after completion of NSRCT were compared between the six different regions of Taiwan by analysis of variance (ANOVA), and between hospitals and private clinics in each of the six regions by Student's *t* test. A *p* value of less than 0.05 was considered statistically significant for all tests.

Results

A total of 1,588,217 teeth treated with NSRCT in 2000 were evaluated. First untoward events occurred in 192,488 (12.1%) teeth during a 5-year follow-up period. Nonsurgical retreatment was performed for 69,273 (36.0%) of these teeth, 4741 (2.5%) received apical surgery, and 118,474 (61.5%) were extracted. At the end of the follow-up period, 124,905 (7.9%) teeth were extracted, which yielded a 5-year tooth retention rate of 92.1% for all NSRCT teeth. Of these 124,905 teeth, 5869 (4.7%) were extracted after nonsurgical retreatment, 562 (0.4%) after apical surgery, and 118,474 (94.9%) at the first untoward event (Table 1).

A total of 124,905 teeth, including 24,499 (19.6%) anterior teeth, 33,356 (26.7%) premolars, and 67,050 (53.7%) molars were extracted. In both hospitals and private clinics, there was a trend where more molars than anterior teeth or premolars were extracted. There were significantly more molars (54.5% *vs.* 43.3%) and significantly fewer anterior teeth (19.0% *vs.* 27.5%) extracted in the private clinics than in hospitals ($p < 0.001$, Table 2).

There was a significant difference in the tooth extraction rate between six different regions of Taiwan ($p < 0.001$, χ^2 test). The east region had the highest tooth extraction rate (10.4%) and the Taipei region had the lowest (7.5%, Table 3). The overall tooth extraction rate was significantly greater in hospitals (10.0%) than in private clinics (7.7%, $p < 0.001$). The individual tooth extraction

Table 1. Relationship between total number of follow-up cases and the first untoward events after completion of nonsurgical endodontic treatment*

All teeth	First untoward events			Total
	Nonsurgical retreatment	Apical surgery	Extraction	
Extraction cases ($n = 124,905$)	5869 (4.7)	562 (0.4)	118,474 (94.9)	124,905 (100.0)
Non-extraction cases ($n = 1,463,312$)	63,404 (93.8)	4179 (6.2)	0 (0)	67,583 (100.0)
Total follow-up cases ($n = 1,588,217$)	69,273 (36.0)	4741 (2.5)	118,474 (61.5)	192,488 (100.0)

*Data presented as n (%).**Table 2.** Comparison of the number of extracted anterior teeth, premolars and molars between hospitals and private clinics*

	All teeth	Anterior teeth	Premolars	Molars	χ^2 test
Hospital type					$p < 0.001$
Hospital	8529 (100.0)	2348 (27.5)	2490 (29.2)	3691 (43.3)	
Private clinic	116,376 (100.0)	22,151 (19.0)	30,866 (26.5)	63,359 (54.5)	
Total	124,905 (100.0)	24,499 (19.6)	33,356 (26.7)	67,050 (53.7)	

*Data presented as n (%).**Table 3.** Tooth extraction rates in six different regions of Taiwan according to hospital type*

All teeth	Taipei region	North region	Central region	South region	Kaoping region	East region	Total
Hospitals							
Extracted teeth	2429	1488	1973	809	1464	366	8529
Total teeth	25,903	15,216	18,441	9551	13,117	3159	85,387
Extraction rate	9.4%	9.8%	10.7%	8.5%	11.2%	11.6%	10.0%
p^\dagger	<0.001	<0.001	<0.001	0.026	<0.001	0.026	<0.001
Private clinics							
Extracted teeth	39,933	15,803	23,744	16,331	17,755	2810	116,376
Total teeth	538,589	206,951	299,835	208,341	221,811	27,303	1,502,830
Extraction rate	7.4%	7.6%	7.9%	7.8%	8.0%	10.3%	7.7%
Overall							
Extracted teeth	42,362	17,291	25,717	17,140	19,219	3176	124,905
Total teeth	564,492	222,167	318,276	217,892	234,928	30,462	1,588,217
Extraction rate	7.5%	7.8%	8.1%	7.9%	8.2%	10.4%	7.9%

*Data presented as n or %; † comparison of tooth extraction rate between hospitals and dental clinics in different regions of Taiwan using the χ^2 test.

rate in all six regions of Taiwan was also significantly greater in hospitals than in private clinics (Table 3). However, tooth extraction procedures were nearly evenly distributed over the follow-up of 5 years, with the annual incidence being close to 20%. This trend was similar in each of the six different regions of Taiwan (Table 4).

A significant difference in the mean tooth extraction time was found between the six different regions of Taiwan ($p < 0.001$, ANOVA). Kaoping and east regions had the lowest mean tooth extraction time (2.44 ± 1.44 and 2.44 ± 1.45 years, respectively), whereas Taipei had the highest (2.54 ± 1.43 years, Table 5). The overall mean tooth

Table 4. Distribution of tooth extraction cases in each of the 5 follow-up years according to the six different regions of Taiwan*

Region	1 st year	2 nd year	3 rd year	4 th year	5 th year	Total
Taipei	7888 (18.6)	8560 (20.2)	8588 (20.3)	8731 (20.6)	8595 (20.3)	42,362 (100.0)
North	3614 (20.9)	3444 (19.9)	3474 (20.1)	3388 (19.6)	3371 (19.5)	17,291 (100.0)
Central	4886 (18.6)	5194 (20.4)	5280 (20.8)	5160 (20.6)	5197 (20.9)	25,717 (100.0)
South	3123 (18.2)	3544 (20.7)	3535 (20.6)	3480 (20.3)	3458 (20.2)	17,140 (100.0)
Kaoping	3977 (20.7)	4049 (21.1)	3953 (20.6)	3633 (18.9)	3607 (18.8)	19,219 (100.0)
East	670 (21.1)	683 (21.5)	601 (18.9)	619 (19.5)	603 (19.0)	3176 (100.0)
Total	24,158 (19.3)	25,474 (20.4)	25,431 (20.4)	25,011 (20.0)	24,831 (19.9)	124,905 (100.0)

*Data presented as n (%).

Table 5. Mean tooth extraction times after completion of nonsurgical endodontic treatment in six different regions of Taiwan according to hospital type

Hospital type	Mean tooth extraction time \pm standard deviation (yr)						
	Taipei region	North region	Central region	South region	Kaoping region	East region	Total
Hospitals	2.35 \pm 1.51 (n = 2429)	2.18 \pm 1.52 (n = 1488)	2.31 \pm 1.51 (n = 1973)	2.30 \pm 1.47 (n = 809)	2.24 \pm 1.48 (n = 1464)	2.41 \pm 1.43 (n = 366)	2.29 \pm 1.50 (n = 8529)
<i>p</i> *	<0.001	<0.001	<0.001	<0.001	<0.001	0.709	<0.001
Private clinics	2.55 \pm 1.43 (n = 39,933)	2.49 \pm 1.44 (n = 15,803)	2.54 \pm 1.43 (n = 23,744)	2.55 \pm 1.42 (n = 16,331)	2.45 \pm 1.44 (n = 17,755)	2.44 \pm 1.45 (n = 2810)	2.52 \pm 1.43 (n = 116,376)
Overall	2.54 \pm 1.43 (n = 42,362)	2.46 \pm 1.45 (n = 17,291)	2.52 \pm 1.44 (n = 25,717)	2.53 \pm 1.42 (n = 17,140)	2.44 \pm 1.44 (n = 19,219)	2.44 \pm 1.45 (n = 3176)	2.50 \pm 1.44 (n = 124,905)

*Comparison of mean tooth extraction time between hospitals and dental clinics in different regions of Taiwan using Student's *t* test.

extraction time was 2.50 \pm 1.44 years after completion of NSRCT for all teeth, and was significantly greater in private clinics (2.52 \pm 1.43 years) than in hospitals (2.29 \pm 1.50 years, *p* < 0.001). Furthermore, the individual mean tooth extraction time in each of the six regions of Taiwan was also significantly greater in private clinics than in hospitals (Table 5).

Discussion

Recently, an epidemiological model with a very large sample size was used to evaluate endodontic treatment outcome.^{2,3} In this type of study, tooth retention becomes an evaluative criterion for the clinical outcome of NSRCT. Three recent studies have evaluated tens of thousands to more than one million NSRCT cases.²⁻⁴ Lazarski et al reported that 94.4% of NSRCT teeth remained

functional over an average follow-up period of 3.5 years.² Salehrabi and Rotstein found that 97% of teeth were retained in the oral cavity 8 years after initial NSRCT.³ Our recent study showed that 92.9% of 1,557,547 teeth treated in Taiwan in 1998 were retained in the oral cavity 5 years after NSRCT.⁴ The 5-year tooth retention rate of 92.1% in the present study was comparable to that (92.9%) in our recent study.⁴ Other follow-up investigations by Friedman and Mor revealed that 91-97% of endodontically treated teeth remained functional over time.¹ The results of the above studies indicate a high tooth retention rate of > 91% after NSRCT. It appears reasonable to conclude that NSRCT is a valuable dental procedure because of the high tooth retention rate.

Epidemiologic studies also provide some information on the group of teeth experiencing an untoward event. Here, we found that 61.5% of the 192,488 teeth with the first untoward event

were extracted during the 5-year follow-up period. This result was comparable to the corresponding result (65.5%) of our previous study.⁴ Lazarski et al reported that 59% of 4212 teeth that suffered a first untoward event were extracted over a minimum follow-up interval of 2 years.² Salehrabi and Rotstein also demonstrated that 73.5% of 57,361 teeth with the first untoward events were extracted.³ All four of these studies indicate that tooth extraction is the most common initial untoward event following NSRCT.

The frequency of apical surgery after NSRCT was 15% and 16.4% in the studies of Lazarski et al² and Salehrabi and Rotstein,³ respectively, with both rates higher than the 2.5% and 2.7% demonstrated in our present and previous studies,⁴ respectively. In the USA, endodontics is one of the American Dental Association's recognized specialties. Lazarski et al found that approximately 70% of all apical surgery following NSRCT is performed by endodontists in the USA.² In Taiwan, apical surgery is considered a high-level technique that is always taught in postgraduate courses, and therefore, it is performed mostly by endodontists or oral surgeons. Thus, global differences in endodontic training may contribute to differences in the rates of apical surgery versus tooth extraction.

In this study, more molars than anterior teeth or premolars were extracted in hospitals and private clinics. Our previous study evaluated the technical quality of NSRCT in Taiwan and showed that significantly more molars have poor endodontic work compared to that of anterior teeth and premolars in both hospitals and private clinics.⁶ This might explain why more molars than anterior teeth or premolars were extracted in the present study. In Taiwan, more well-trained endodontists work in hospitals than in private clinics, which results in a higher percentage of teeth receiving good endodontic work being found in hospitals rather than in private clinics.⁶ Easier endodontic cases are treated in private clinics rather than in hospitals, and the majority of difficult or failed endodontic cases are referred to hospitals for treatment. Moreover, dentists may feel more

comfortable performing apical surgery in the anterior regions than in the premolar or molar areas because of better visibility and easier access in the former. The above-mentioned reasons partially explain why there were significantly more molars and significantly fewer anterior teeth extracted in private clinics than in hospitals, why the overall tooth extraction rate was significantly greater in hospitals than in private clinics, and why the overall mean tooth extraction time after completion of NSRCT was significantly greater in private clinics than in hospitals.

The nonsurgical-retreatment frequency was 36%, which was comparable to that (31.7%) of our previous study,⁴ but higher than that determined by Lazarski et al² (26%) and Salehrabi and Rotstein (10.1%).³ There are several explanations for this finding. First, approximately 70% of the teeth treated with NSRCT in Taiwan were either inadequately filled or incompletely obturated, as evaluated by radiographic surveys.⁶ When performing prosthodontic work on improperly treated teeth, the dentist may favor nonsurgical retreatment in order to improve the prognosis. Second, nonsurgical retreatment is covered by the NHI in Taiwan; therefore, patients may initially prefer this conservative treatment modality. Third, compared to their US counterparts, dentists in Taiwan may lack the training necessary for apical surgery, so are more likely to perform nonsurgical retreatment.

In conclusion, tooth extraction (61.5%) is the most common procedure among the three first untoward events. Approximately 95% of tooth extraction procedures are performed at the first untoward event, and the remaining 5% are performed after initial nonsurgical retreatment or apical surgery. NSRCT is still a valuable dental procedure because of the high rate (92.1%) of tooth retention 5 years after NSRCT in Taiwan.

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