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Assessment of knowledge on traumatized immature permanent teeth among dentists in China: a cross-sectional study



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Abstract

Objective Medical practice is always based upon the cognition and knowledge base of physicians, and the same applies to dentistry. Being attained through education and perception, knowledge is essential to clinical practice. Cross-sectional studies have recognized a uniform trend in which the treatment of traumatic dental injuries (TDIs) is of suboptimal quality in China: is a lack of knowledge a problem, or do some relevant factors of dentists have a significant effect on obtaining TDI treatment knowledge? The purpose was to measure dentists' knowledge of TDI treatment and investigate whether some relevant factors have indeed affected their knowledge of TDI treatment.

Method An online-based cross-sectional study was conducted among 1027 dentists in Guangxi Province via a cluster sampling technique. Descriptive and inferential statistics, including frequency, percentage, *t* test, ANOVA test and linear analysis, were obtained. The results were interpreted via tables and graphs.

Results Studies that measured dentists' knowledge of TDI treatment, which was valuable, reliable, and had practical implications that could be implemented. A total of 1027 questionnaires from 14 main districts in Guangxi were used to measure the knowledge level of local dentists and potential influencing factors via 40 questions at 20 TDI treatment-related points.

Conclusion Findings from the present study revealed that the degree of knowledge among dentists in Guangxi regarding the treatment of traumatized immature permanent teeth is moderate. The findings further revealed a significant relationship between factors such as sex, education level, professional title, and the workplace of dentists and higher scores on the questionnaire (P < 0.001).

The clinical significance of the TDI treatment knowledge of dentists in Guangxi Province was found to be moderate and variable. This may limit the quality of effective treatment. However, providing information without attention to differences among dentists caused by influencing factors that significantly affect dentists' cognitions and motivations

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may not be successful. Educational strategies and goals should be re-evaluated, and relevant continuing education measures should be tailored to local conditions.

Keywords Dentists, Immature permanent teeth, Tooth injuries, Emergency, Knowledge bases

Introduction

Knowledge is a fundamental necessity for the practice of clinical medicine, which also includes dentistry. Current knowledge is needed for evidence-based practice. Instead of a simple collection of data or words, knowledge requires interpretation of its inner aspect and the facility for its implementation through activities such as clinical practice [1]. In healthcare, knowledge comprises not only detailed, explicit and objective information on topics such as patients' disease etiology, prevalence, risk factors, prevention, symptoms, and treatment of patients but also information from some other doctors, which might have been ignored [2].

Indeed, knowledge is fundamental to the provision of healthcare. While longitudinal data, primarily from academic institutions, indicates that standardized management of traumatic dental injury (TDI) may yield excellent clinical outcomes, cross-sectional data from real-world communities suggests that the quality of actual treatment is often suboptimal, with clinical outcomes falling short of the ideal [3]. Could the lack of relevant knowledge among dentists be a main factor limiting the effectiveness of TDI treatment? Although similar issues have received attention in medical practice [4-6], research into dentists' cognition remains in its infancy, with existing literature fragmented and unsystematic, especially on TDIs. To better understand the impact of dentists' knowledge levels on clinical outcomes for TDI, a new study with multifactorial analysis needs to be proposed.

TDI refers to acute injury to dental hard tissues, pulp, or periodontal tissues caused by a sudden mechanical force impact [7]. Immature permanent tooth trauma accounts for 50-70% of all dental traumas in permanent dentition and mostly occurs at the age of 7-9 years. It is the second most prevalent dental disease that causes permanent tooth loss or avulsion in children, following dental caries [8]. The incidence of dental trauma varies among different countries and regions. For example, a study conducted by domestic researchers in Xi'an city reported a prevalence of 10.5% and a dental trauma treatment rate of 38.2% among school-aged children, with an unfavourable prognosis rate of 29.7% [9, 10]. The main reason for this phenomenon is that insufficient awareness of dental trauma in the general population results in inadequate knowledge of dental trauma management [11]. Additionally, insufficient knowledge from healthcare professionals regarding the management of crown fractures, avulsion injuries and luxation injuries can lead to unsatisfactory treatment and prognoses [4, 12].

Moreover, some researchers believe that factors such as sex, years of clinical experience, and educational background also influence the level of dental trauma awareness among dentists [13]. For instance, people in China generally believe that more experienced doctors possess superior medical skills.

In addition, owing to differences in various factors among the study population, there are different reports on the prevalence of common types of dental trauma. One survey revealed that the most common type of dental trauma was enamel fracture (31.5%), followed by subluxation (16.4%) and lateral luxation (13.2%) [14]. Additionally, the most common types of dental trauma caused by sports activities are subluxation (24.3%) and complicated crown fractures (12.4%) [15], with the maxillary central incisors being the most commonly affected teeth (84.8%) [16]. Owing to the large root canal and incompletely developed apex, immature permanent teeth and young permanent teeth are more difficult to treat after trauma. The pain caused by dental trauma can increase dental fear and noncooperation in pediatric patients, thereby increasing treatment difficulty. Research has shown that dental trauma in children can have negative impacts on their overall health and quality of life [10, 17]. Prompt and appropriate treatment can effectively mitigate the damage caused by these adverse impacts.

To promote standardized treatment procedures, the International Association of Dental Traumatology (IADT) published the first edition of the Guidelines for Dental Trauma Management in 2001 [18]. Updated versions were subsequently released in 2007 [19-21] and 2012 [22-24]. The most recent edition of the Dental Trauma Guidelines was published in June 2020 [25–27]. This latest version underwent substantial revisions compared with the 2012 edition. However, the dissemination and adoption of these guidelines in China have been relatively unsatisfactory, limiting their impact. Owing to the anatomical characteristics of immature permanent teeth, the difficulty of their treatment increases. Currently, there is limited research on the management of immature permanent tooth trauma domestically in China. To address these issues, this questionnaire was designed to obtain a clear view of the present situation of the awareness and clinical management skills of dentists regarding immature permanent tooth trauma and aims to lay the foundation for improving the level of care, diagnosis, and treatment capabilities specific to this type of dental trauma. This questionnaire provides different training advice for specific groups of doctors, with the goal of improving the cognitive level, treatment and prognosis of young permanent tooth injuries within a certain period of time. To achieve this goal, an investigation of the knowledge among dentists in Guangxi regarding the treatment of traumatized immature permanent teeth and related factors was established in this study.

Materials and methods

Human Ethics and Consent to Participate declarations Before the investigation, this research was approved by the Scientific and Ethics Commissions of the College of Guangxi Medical University (*NO. 2020027*). The present research was conducted in full accordance with ethical principles.

The analysis of the collected human data in this study adheres to the Helsinki Declaration.

Study participants

This study enrolled assistant practicing dentists, practicing dentists and specialist dentists who belonged to different disciplines and was working in public hospitals, faculties of dentistry, and private clinics in Guangxi as survey subjects, and samples were selected according to the following criteria:

Inclusion criteria Dental practitioners in the Guangxi Zhuang Autonomous Region who obtained a Medical Practitioner Qualification or Assistant Medical Practitioner Qualification before 2021.

Exclusion criteria Those who do not meet the above conditions, do not consent to participate in the survey, or fail to complete the questionnaire as required.

Sample size estimation

The sample size was estimated on the basis of the knowledge rate of the treatment for traumatized immature permanent teeth among dental practitioners and the allowable error. The formula for estimating the sample size in the current survey is $N=t^2PQ/d^2$, with the following parameter values: N is the sample size, P is the knowledge rate, and Q = 1-P. Currently, the reported accuracy rates of various types of dental trauma management knowledge range from 17 to 89% [13]. To obtain a larger sample size, assuming P = 30%, d is the allowable error and was set to 10%, i.e., d = 0.1P. The confidence level was set at 95% for both sides, and t = 1.96. Plugging in the above values into the formula, the sample size was estimated to be $N=1.96^2 \times 0.3 \times (1-0.3)/(0.1 \times 0.3)^2 = 896$. To ensure an adequate sample size, with regard to the response rate of the dentists (10%), the sample size was expanded to 986 individuals.

Questionnaire design

Owing to the complexity of the treatment of immature permanent tooth injuries, the survey questionnaire was designed by referring to the relevant literature and books on dental trauma at home and abroad [7, 8, 22–29], especially the updated and modified content of the 2012 and 2020 guidelines, which mainly targeted immature permanent tooth injuries. The questionnaire was finalized after discussions and modifications by two groups of paediatric dentists and emergency dentists.

The questionnaire (in supplementary information) consisted of two parts. The first part included demographic information and professional profiles, including sex, education level, job title, work unit, years of work experience, city of work, specialty in dentistry, number of injured immature permanent tooth cases treated per year, and training in dental trauma management and learning channels for dental trauma knowledge. The second part consisted of questions related to the management of immature permanent tooth trauma, including imaging examinations (1 question), treatment of tooth fracture (2 questions), treatment of pulp exposure after tooth fracture (5 questions), and treatment of luxation injuries (13 questions).

The questions related to the management of immature permanent tooth trauma included both single-choice and multiple-choice questions. Each correct answer was given one point, and the score for each question was the sum of the number of correct answers (1 to 8 points). The total score for the questionnaire was the sum of all correct answers, with a maximum score of 47. No points were deducted for incorrect answers. A higher total score indicates a better understanding of dental trauma management.

Online data collection

On the basis of relevant data on the distribution of dental resources in Guangxi and the annual growth rate [26], it is estimated that there was a total of 4,102 dentists (including dental assistants) in Guangxi in 2020. According to the data provided by the Guangxi Stomatological Association, there were 3,220 members in the association in 2020, indicating that the membership covered 78.2% of the dentists in Guangxi. For this study, relevant information was collected through electronic surveys distributed among members of the Guangxi Stomatological Association.

An electronic questionnaire was delivered online to the dentists on a voluntary basis from December 2nd to December 31st, 2020, which was distributed using the snowball recruitment method to facilitate its rapid dissemination among dental practitioners. It is important to note that the questionnaire automatically generated when a user accesses the filling interface, but the content is only recorded and collected after the user completes all fields and chooses to submit. If the user leaves the questionnaire incomplete or does not submit it, the system will void the questionnaire without leaving any record. The questionnaire was distributed via the Questionnaire Star system of WeChat APP to ensure that the anonymity of the respondents' participation in this study was ensured.

Before the questionnaire was distributed, a pilot survey was conducted with a random selection of 50 dentists to test the questionnaire and survey format. Those individuals who participated in the pilot survey were not included in the final research sample.

Data analysis

All the statistical analyses were performed via SPSS statistical software v.25.0 (IBM, Armonk, NY, US).

Descriptive analysis: First, the composition ratio (%) was used for analysis, and then the mean±standard deviation and the awareness rate were used for analysis. The awareness rate (%) was calculated as the number of correct answers divided by the total number of questionnaire items (actual score/total score) multiplied by 100%. The awareness rate was categorized as follows: scores below 40% were defined as poor, scores between 40% and 80% were defined as moderate, and scores higher than 80% were defined as good [30, 31].

Univariate analysis revealed that the distribution of knowledge scores of dental majors was expected to be normal. The *t* test and ANOVA were used to compare the knowledge score distributions among different variables.

Multivariate analysis Multiple linear regression analysis was used to identify factors related to knowledge scores. In addition, the variance inflation factor (VIF) was used to measure the severity of multicollinearity in the multiple linear regression model.

The significance level for two-sided tests was set at 0.05, with a p value < 0.05 considered statistically significant.

Results

As presented in Table 1, the survey yielded a total of 1,027 valid questionnaires after automated screening and manual verification conducted through the online platform "Questionnaire Star". As the program is designed not to upload incomplete or unsubmitted entries, the completion rate of this questionnaire was 100% and the response rate was unclear. The sample covered all prefecture-level cities in Guangxi, with participating healthcare providers closely matching the actual distribution. The sample size met expectations and was representative.

Table 2 shows the frequency distributions of sociodemographic and professional variables. Only 42.6% of participants have received dental trauma management training. Among surveyed dentists, 60.3% were female. By education, 22.2% held an associate degree or lower, 54.4% had a bachelor's degree, and 23.4% had a master's or doctoral degree. For professional titles, 51.6% held junior or lower titles, and 64.2% worked in public hospitals. By experience, 36.2% had \leq 5 years, 53.2% had 6–20 years, and 10.6% had > 20 years. Additionally, 58.8% were based in the northern bay region, 73.9% practiced general dentistry, 78.3% treated \leq 15 dental trauma cases annually, and 57.4% had no dental trauma training.

The responses to the questionnaires revealed an average knowledge score of 27.3 ± 5.8 (40-80%), indicating a moderate overall level of understanding (Table 3). Specifically, the average scores for treatment knowledge include imaging examination, crown fracture, crown fracture involving the pulp, and avulsion were 1.3 ± 0.7 , 3.6 ± 1.9 , 5.3 ± 1.8 , and 17.1 ± 3.6 , respectively, all reflecting moderate knowledge.

Table 4 shows varying knowledge levels among Guangxi dentists regarding immature permanent tooth trauma management. Awareness rates were below 40% for Q2, Q12, Q13, Q15, and Q17; 40-80% for Q1, Q3–Q11, Q14, Q16, Q18, and Q19; and above 80% for Q20. This suggests a generally moderate overall knowledge but significant room for improvement.

On the basis of the feedback from the questionnaire summarized in Table 4, the level of knowledge among dentists in Guangxi regarding the management of various

lable 1	Distribution	of cities in	Guangxi and	number of dentists

Cities in North Bay	N (%)	N (%)	Cities out of North Bay	N (%)	N (%)
Nanning	1356/33.1	416/40.5	Guigang	122/3.0	69/6.7
Beihai	312/7.6	34/3.3	Hezhou	89/2.2	17/1.7
Chongzuo	105/2.6	25/2.4	Wuzhou	120/2.9	23/2.2
Fangchenggang	144/3.5	21/2.0	Baise	328/8.0	79/7.7
Qinzhou	146/3.5	45/4.4	Hechi	233/5.7	72/7.0
Yuling	279/6.8	63/6.1	Guiling	410/10.0	90/8.8
-	-	-	Liuzhou	268/6.5	51/5.0
-	-	-	Laibing	190/4.6	22/2.1
Total	2342/57.1	604/58.8	Total	1760/42.9	423/41.2

Та	b	e 2	Frequency	distribution	of different	variables	(N = 1027)

Variable	N	Per- cent- age (%)
Sex		
Male	408	39.7
Female	619	60.3
Education level		
Diploma or lower education	228	22.2
Bachelor's degree	559	54.4
Master's or doctoral degree	240	23.4
Professional title		
Junior and below	530	51.6
Intermediate or higher	497	48.4
Institution		
Public hospitals	654	64.2
Private institutions	365	35.8
Years of work experience		
≤5 years	372	36.2
6–19 years	546	53.2
≥20 years	109	10.6
Work region		
North Bay district	604	58.8
Other districts	423	41.2
Dental specialty		
General dentistry	759	73.9
Maxillofacial surgery, periodontal mucosa, endodon- tics, and paediatric dentistry	150	14.6
Prosthodontics, orthodontics and other	118	11.5
Number of dental trauma cases treated annually		
≤15 cases	804	78.3
>15 cases	223	21.7
Participated in dental trauma management training		
No	589	57.4
Yes	438	42.6

Table 3 Scores of dentists in Guangxi on knowledge related to the management of traumatized immature permanent teeth (N = 1027)

Variable	Score range	Average	Standard deviation	Scoring aver- age (%)
Total score(47 pt)	7.0~41.0	27.3	5.8	58.1
Imaging examination(3 pt)	0.0~3.0	1.3	0.7	43.3
Tooth fracture treat- ment(8 pt)	1.0~8.0	3.6	1.9	45.0
Treatment for tooth fracture with pulp expo- sure(9 pt)	1.0~9.0	5.3	1.8	58.9
Treatment for dental avulsion(27 pt)	3.0~25.0	17.1	3.6	68.4

"pt" refers to the points set for the test

Table 4 Questions about knowledge related to the management of traumatized immature permanent teeth

Question	estion Knowledge related to the management of traumatized	
	immature permanent teeth	rate (%)
Q1	Imaging examination	43.3
Q2	Time of first review after resin repair of uncompli- cated crown fracture	13.7
Q3	Uncomplicated root crown fractures	49.2
Q4	Pulp capping materials for complicated crown fractures	55.7
Q5	Treatment for crown fracture with pulp exposure aperture less than 1 mm and less than 24 h	74.9
Q6	Treatment for crown fracture with pulp exposure aperture more than 1 mm within 24 to 72 h	77.4
Q7	Treatment for crown fracture with pulp exposure aperture more than 1 mm and more than 72 h	52.0
Q8	Management of dental concussion	50.3
Q9	The time of elastic fixation for luxated teeth with alveolar fracture but without root fracture	47.8
Q10	Treatment of lateral luxation	54.5
Q11	Treatment of intrusive luxation with a depth of approximately 1/3 of the crown	79.1
Q12	Treatment of intrusive luxation with a depth of more than 2/3 of the crown	24.9
Q13	When orthodontic traction should begin for intrusive luxated teeth	23.1
Q14	Alveolar treatment before replantation of avulsed teeth with alveolar fracture for less than one hour	79.7
Q15	Time of elastic fixation for the replanted teeth with avulsion of less or more than one hour	15.3
Q16	Avulsed teeth (NOLLA VIII) with secondary pulp necrosis	47.0
Q17	Best time of endodontic treatment for teeth avulsed for more than one hour	32.8
Q18	Storage mediums for avulsed teeth	79.2
Q19	Necessity of systemic application of antibiotics after replantation of avulsed teeth	51.4
Q20	Factors influencing the success of replantation	82.5

types of immature permanent tooth trauma varied significantly. The analysis shows that awareness rates were below 40% for Q2, Q12, Q13, Q15, and Q17; 40-80% for Q1, Q3–Q11, Q14, Q16, Q18, and Q19; and above 80% for Q20. These results suggest that while Guangxi dentists generally possess a moderate level of knowledge regarding the management of traumatized immature permanent teeth, there remains substantial room for improvement in certain areas.

Univariate analysis (Table 5) found significant differences in knowledge scores by gender, education, professional title, institution type, experience, specialty, annual trauma cases, and training. Male dentists scored lower than females (26.3 vs. 28.0, P<0.001). Dentists with diplomas scored lower than those with bachelor's degrees, who scored lower than those with master's/

Table 5 Comparison of the distribution of scores on immature permanent tooth trauma management among various influencing factors (N = 1027)

Variable	Score	Average	SE	T/F	Р
	range range	5			
Sex				-4.557	0.000*
Male	7.0~41.0	26.3	6.0		
Female	7.0~41.0	28.0	5.5		
Education level ${\bigtriangleup}$				61.421	0.000**
College or lower education	7.0~35.0	24.0	5.6		
Bachelor's degree	9.0~41.0	27.8	5.4		
Master's or doctoral degree	9.0~41.0	29.4	5.6		
Professional titles				-4.894	0.000*
Junior and below	7.0~41.0	26.5	6.0		
Intermediate or high-	9.0~41.0	28.2	5.4		
er					
Institution				8.501	0.000*
Public hospitals	9.0~41.0	28.5	5.4		
Private institutions	7.0~41.0	25.4	5.9		
Years of work experience▲				6.302	0.002**
\leq 5 years ^a	9.0~41.0	27.4	5.9		
6–19 years ^b	7.0~41.0	27.7	5.5		
≥20 years ^c	7.0~39.0	25.5	6.5		
Work region				0.206	0.837*
North Bay district	7.0~41.0	27.4	5.8		
Other districts	7.0~41.0	27.3	5.7		
Dental specialty⇔				7.099	0.001**
General dentistry ^e	7.0~41.0	27.2	5.7		
Maxillofacial surgery, periodontal mucosa, endodontics, and pae- diatric dentistry <i>f</i>					
endodontics, and paediatric dentistry	13.0~41.0	28.9	5.6		
Prosthodontics, or- thodontics and other ^g	7.0~38.0	26.5	6.1		
Number of dental trauma cases treated annually				-2.494	0.013*
≤15 cases	7.0~41.0	27.1	5.6		
>15 cases	7.0~41.0	28.2	6.1		
Participated in dental trauma management training				-2.011	0.045*
No	7.0~40.0	27.0	5.7		
Yes	7.0~41.0	27.8	5.8		

"*" indicates t test, "**" indicates ANOVA test.

 \triangle : *P*<0.001 for all pairwise comparisons among the three groups.

: P=0.522 for comparison between a and b, P=0.003 for comparison between a and c, P<0.001 for comparison between b and c.

>: P = 0.001 for comparison between e and f, P = 0.001 for comparison between f and g, P = 0.223 for comparison between e and g

Table 6 Multiple linear regression analysis of related factors that affected scores for the management of immature permanent tooth trauma (N= 1027)

Variable	B (95% CI)	P value
Sex		
Male	1.00(reference)	
Female	1.371(0.690~2.053)	0.000
Education level		
College or lower education	1.00(reference)	
Bachelor's degree	2.825(1.903~3.747)	0.000
Master's or doctoral degree	4.052(2.895~5.209)	0.000
Professional ranks and titles		
Junior and below	1.00(reference)	
Intermediate or higher	0.921(0.234~1.608)	0.009
Workplace		
Public hospitals	1.00(reference)	
Private institutions	1.181(0.372~1.991)	0.004

Note: In the initial model, the following variables were included: sex, educational level, professional title, workplace, years of experience, working city, dental specialty, number of annual trauma cases, and whether the practitioner received trauma management training. For categorical variables with no inherent order, dummy variables were created. The reference groups were set as follows: male for sex, diploma or below for educational level, junior or below for professional title, private institution for workplace, more than 20 years for years of experience, North Bay area for working city, orthodontics and restorative dentistry for dental specialty, more than 15 trauma cases per year for number of annual trauma cases, and no trauma management training for the reference group

doctoral degrees (24.0 vs. 27.8 vs. 29.4, P < 0.001). Junior title holders scored lower than senior title holders (26.5 vs. 28.2, P < 0.001). Private institution dentists scored lower than public hospital dentists (25.4 vs. 28.5, P < 0.001). Dentists with > 20 years of experience scored lower than those with ≤ 5 years, both scoring lower than those with 6–20 years (25.5 vs. 27.4 vs. 27.7, P = 0.002). Specialists in prosthodontics, orthodontics, etc., scored lower than general dentists, who scored lower than maxillofacial, periodontal, endodontic, and pediatric specialists (26.5 vs. 27.2 vs. 28.9, P = 0.001). Untrained dentists scored lower than trained ones (27.0 vs. 27.8, P = 0.045). Dentists handling ≤ 15 cases annually scored lower than those handling more (27.1 vs. 28.2, P = 0.013). No significant differences were found by city (P > 0.05).

Multiple linear regression analysis revealed that dentist sex, educational level, professional title, and type of institution were significantly associated with knowledge scores. Compared with male dentists, female dentists presented higher knowledge scores, and higher educational levels and professional titles were positively correlated with better knowledge scores (details in Table 6). Additionally, dentists working in public hospitals scored higher than those working in private institutions did. However, other factors, such as years of experience, working city, dental specialty, the number of annual trauma cases, and trauma management training, were not significantly associated with knowledge scores. The variance inflation factor (VIF) values were all less than 5, indicating the absence of multicollinearity among the included variables.

Multiple linear regression linked higher knowledge scores to some specific character 'in Table 6. Individuals with these attributes—female gender, higher educational background, senior professional titles, and employment in public hospitals—appear to score higher than others. Meanwhile, experience, city, specialty, annual cases, and training were not significant. VIF values < 5 indicated no multicollinearity.

Discussion

The data collected reflect the distribution of the surveyed dentists in terms of gender, educational background, professional title, years of experience, work location, area of expertise, and training in dental trauma management, and are summarized and presented in the form of scores. By analysing this information, the demographic characteristics of the surveyed doctors were summarized. The results indicate that the average knowledge score and awareness rate of dental trauma treatment for immature permanent teeth among dentists in Guangxi are only about half of the expected values, suggesting a moderate level of knowledge that still requires improvement.

Imaging examinations such as X-ray, cone beam computerized tomography (CBCT) and 3D imaging provide enhanced visualization of TDIs, particularly root fractures, crown/root fractures, and lateral luxation, in which the radiographs aimed at the maxillary lateral incisors (the most easily injured teeth) provide different horizontal (mesial and distal) views of other incisors, as well as showing the canine teeth, providing a variety of vertical views of them and the surrounding tissues, which is particularly helpful for evaluation and therapy. Moreover, radiographs are necessary to make a thorough diagnosis of dental injuries. Sometimes, invisible tooth root and bone fractures may occur without any clinically observable signs or symptoms, and those undetected may be delayed for several weeks after the trauma occurs with clinical signs of a more serious injury that should have subsided weeks prior, so a radiographic view is needed to reduce undetected injury [32-34]. In this survey, the awareness rate of dental trauma imaging examinations was only 43.3%, indicating that dentists had an inaccurate understanding of different imaging techniques and their indications, suggesting a relatively slow update of knowledge in this area.

The treatment approach for tooth fractures depends on factors such as the location of the fracture line, degree of mobility, involvement of the pulp and presence of alveolar fractures [25, 35]. Concurrent crown fractures significantly increase the risk of pulp necrosis and infection in teeth with concussion or subluxation injuries and mature

root development. Similarly, crown fractures with or without pulp exposure significantly increase the risk of pulp necrosis and infection in teeth with lateral luxation, indicating that multiple fractions occurring at the same time in different places on one tooth will be more detrimental than a single injury, leading to a worse synergistic condition [36-38]. Some data revealed that dentists in Guangxi have relatively low knowledge (45%) about the treatment of tooth fracture, the awareness rate of treatment for crown fractures with pulp exposure (55.9%) is also far from satisfactory. In some similar research below, for example, a percentage of 48% correct answers regarding the treatment of choice for crown fractures was found in Australia in 2022 [39]. In Turkey, a higher percentage of correct answers regarding the clinical signs of crown fractures (60.8%) compared to our study was found [40]. The study from Brazil can provided an even higher percentage (75.3%) [41]. In India, a study found that dentists who specializing in General Dentistry, appear to get a higher percentage of correct answers (65%) concerning crown fractures with pulp exposure compared to our present work [42]. Actually, with sufficient blood supply in the pulp, open apices, and no age-related changes in the pulp of immature permanent teeth, timely conservative treatments such as direct pulp capping or pulpotomy after trauma can generally maintain a satisfactory pulp survival rate [43]. The significantly lower awareness rate of knowledge compared to other regions is bound to lead to a decline in treatment success rates, leading to treatment failure and final extraction.

Different directions and magnitudes of external forces applied to teeth can result in various types of injuries and tooth luxation, which can also cause situations such as pulp necrosis and damage to periodontal supporting tissues [3]. The type and severity of tooth luxation determines the treatment plan. Typically, the pulp of fractured and luxated immature teeth may survive and heal, or spontaneous pulp revascularization may occur following luxation. Thus, root canal treatment should be avoided unless there is clear clinical or radiographic evidence of pulp necrosis or infection. Nevertheless, regular tests after treatment are mandatory, so root canal treatment can be commenced as soon as this type of resorption is detected, especially for immature permanent teeth, which still have a greater risk of pulp necrosis and infection after traumatic injury with crown fracture.

Compared with the similar studies in Spain [44] and Lithuania [45], it is observed that the knowledge regarding treatment of avulsion of immature permanent teeth was very high (79.2% of answers are correct), which is consistent with previous reports. It is reported that above 95% of dentists in Barcelona would recommend parents immediately replant the tooth once the accident happened, and if there were no nearby clinic, store the tooth in saliva or cold milk and go to the hospital [44]. Milk has been proven to be an effective medium for maintaining the periodontal ligament cell in avulsed tooth viability in sudden situations and consequently avoid ankylosis or root resorption when they are storing in a dry bottom or with other non-physiological solutions. Interestingly, doctors from different countries seem to exhibit varying tendencies in their knowledge of tooth avulsion. In a report on storage media for avulsed teeth, 100% of dentists in the United Arab Emirates chose milk [46], while the figures were 74.7% in Italy [47], 15.8% in China [48], and 11.2% in Germany [49]. However, the data for Chinese dentists in this report significantly differs from the findings of this survey (91.9%). This discrepancy may be attributed to differences in textbooks across countries. Given that milk is far more accessible than Hanks' balanced salt solution, it is understandable why many dentists recommend it to parents and teachers.

The overall level of knowledge related to immature permanent tooth trauma management among dentists in Guangxi was moderate. However, there were variations in the mastery of this knowledge among different groups of dentists, necessitating an analysis of factors that influence dentists' scores in tooth trauma knowledge. On this basis, further improvement strategies could be developed.

This survey revealed that female dentists had higher knowledge scores than male dentists did. This may be attributed to the larger proportion of women in the population receiving higher education in recent years [35,50]. Additionally, female dentists more commonly work in departments that commonly handle dental trauma, such as endodontics and paediatric dentistry. This means that, on the one hand, the daily work in these departments requires them to keep in mind the relevant knowledge of dental trauma, and on the other hand, the abundant experience in treating dental trauma also gives them a deeper understanding.

It was found that age to be significantly associated with the level of TDI knowledge with younger dentists exhibiting greater knowledge. This agreed with studies from Greece [51], Belgium [52], and Lithuania [45]. those who have work for 6-20 year was also associated with greater knowledge of TDI, with freshman who work less than 5 yeas having a relative lower score, and the group who have worked over 20 years actually received the lowest scores. It is weird because commonly speaking, as dentists gain work experience, knowledge should also be increasing. Our study, however, did not verify this idea, and the same trend has been observed in other countries [51, 52]. Also, dentists with higher educational levels and professional titles tended to have higher knowledge scores. This may be due to the increased opportunities for theoretical learning and expert guidance among those with higher education levels. The promotion of professional titles requires not only sufficient work experience but also passing professional theory assessments. Higher educational levels and professional titles indirectly indicate a more comprehensive understanding of professional theoretical knowledge. Compared with private institutions, public hospitals, some of which have teaching responsibilities, often have higher educational requirements and professional title expectations when recruiting dentists. Therefore, dentists working in public hospitals tended to have higher knowledge scores.

The literature also supports the notion that dentists with higher educational levels and professional titles possess more knowledge about tooth trauma [13, 30-31]. For those who did not work in public healthcare system, selfevaluation may not associate with their level of knowledge, however. Nevertheless, dentists with higher levels of confidence were more likely to respond correctly on how to manage a severe intrusion or sudden condition. Discrepancy between self-assessment and actual knowledge has been reported previously [53, 54], and it could lead to an unrealistic perception of the dentist's competence to treat TDI. In Guangxi autonomous region, this problem could be approached either by referral of complex cases of TDI to Superior hospital/ specialized outpatient department or by developing suitable continuing education courses to improve the dentists' knowledge.

However, this survey revealed that there was no significant association between knowledge scores in tooth trauma and training on tooth trauma management. This finding is inconsistent with existing reports [24, 30]. This may be attributed to the limited number of tooth trauma education courses held in Guangxi in recent years, resulting in inadequate coverage of the population. It is also possible that the short duration of training courses, typically lasting only 2-3 days, is insufficient to provide comprehensive and systematic training to dentists, which needs to get improved. Work experience and the number of tooth trauma cases treated annually were not associated with knowledge scores. This may be because, after eliminating other interfering factors, the influence of work experience and case load on the final scores was minimal. It is important to have a solid foundation of correct knowledge to perform appropriate procedures. Only with proper knowledge can accumulated clinical experience be meaningful. The working city of the dentists was not associated with knowledge scores in this survey. However, it is worth noting that the survey categorized cities without distinguishing between urban and suburban areas. There are reports indicating that dentists in urban areas have greater awareness of tooth trauma knowledge than do those in suburban areas [55].

Furthermore, in this survey approximately three-quarter of the dentists in Guangxi obtained knowledge on tooth trauma during their undergraduate education. The impact of education during the undergraduate period on knowledge scores was greater than that of continuing education, and there was a shortage of postgraduate education. In addition, it is worth mentioning that tooth trauma-related curriculum hours in dental education programs are often limited [8, 56, 57]. Therefore, it is imperative to enhance tooth trauma education during the undergraduate period.

Currently, studies on the management of dental injuries by dental practitioners in China are limited. This study focused on investigating the management of challenging dental injuries in young permanent teeth encountered in clinical practice. This research direction is novel and holds clinical significance. This cross-sectional observational study is one of the few studies to focus on assessing dentists' mastery of the trauma management of young permanent teeth. Because young permanent tooth injuries are more common in the younger population, this study is also one of series of studies on the management of oral tooth injuries in adolescents and children. Moreover, the International Dental Trauma Association released the latest version of the Dental Trauma Guidelines in 2020, which underwent substantial changes compared with the 2012 version. This survey particularly included questions that reflected the level of knowledge among dentists regarding sections of the guidelines that underwent substantial updates, ensuring scientific rigor while promoting innovation. Additionally, this survey utilized the Questionnaire Star online platform, which eliminates the limitations of time and geographical location. This was a more convenient and cost-effective method that did not require substantial human or material resources for data collection.

There were several limitations in this study. First, there is a lack of reference to authoritative questionnaires, as the questionnaire used in this study was independently designed by the research team and may have flaws in its content. Areas for improvement and refinement should be identified and addressed through practical experience. Second, there are limitations associated with conducting an online survey; the use of online surveys introduces certain biases, as it may result in lower response rates among physicians who do not pay attention to mobile messages. This can lead to a biased selection of participants. Third, this survey was limited to Guangxi. Not all group of dentists were enrolled in this region, and further research should consider a survey that involves a larger sample size from other regions.

Similarly, in this survey the collection software requires corresponding improvements to obtain detailed data on the completion and response rates of the questionnaire. These enhancements could include tracking the total number of logins, uploading incomplete questionnaires, and, without involving private information, recording the total number of unsubmitted questionnaires. Such feedback would help analyse the distribution and completion of the questionnaire and improve survey strategies.

Conclusion

The results from the questionnaire indicated that the overall level of knowledge among dentists in Guangxi was moderate and need improve. The level of knowledge regarding immature permanent tooth trauma management is influenced mainly by factors such as sex, educational background, professional title, and institution. Therefore, it is necessary to strengthen education on dental trauma knowledge for dentists with lower educational levels, lower professional titles and those working in private dental clinics, which indicates that education on dental trauma management should be enhanced during the undergraduate curriculum by standardizing treatment protocols.

Supplementary Information

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Supplementary Material 1

Supplementary Material 2

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Author contributions

Z.Q. and K.X. were major contributors to the writing of the manuscript. Z.Q. conducted the study and defined the inclusion and exclusion criteria. Y.L., Y.C., Z.Q., M.W. Y.W. and D.W. conducted the data collection.Z.Q., K.X., and Y.L. analysed and interpreted the data. R.Q. planned the study. All the authors edited and reviewed the draft manuscript and read and approved the final manuscript.

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Data availability

Data is provided within the manuscript or supplementary information files.

Declarations

Human Ethics and Consent to Participate declarations

All procedures performed in this research were in accordance with the ethical standards of the Scientific and Ethics Commissions of the College of Guangxi Medical University (*NO.2020027*). Informed consent was obtained from all individual participants included in the study. The analysis of the collected human data in this study adheres to the Helsinki Declaration.

Consent for publication

Not applicable to this article.

Competing interests

The authors declare no competing interests.

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