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Prevalence, Radiographic Characteristics, and Clinical Outcomes of Impacted Supernumerary Teeth in an Institutional CBCT Cohort

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ABSTRACT

Objectives: To determine the prevalence of impacted supernumerary teeth (ST) detected on cone-beam computed tomography (CBCT) in patients attending the Faculty of Dentistry, Universiti Teknologi MARA (UiTM), to describe their three-dimensional radiographic characteristics, and to examine their association with clinical outcomes. Methods: This retrospective cross-sectional study reviewed 2,589 CBCT examinations acquired between 2016 and 2025. Sixty-eight patients with impacted ST were identified. Dentition stage, number of ST, shape, position, and direction were recorded, together with associated clinical outcomes, including delayed eruption, displacement, spacing, and adjacent root resorption. Descriptive statistics were generated. Associations with clinical outcome were assessed using the chi-square test and binary logistic regression at a significance level of $p < 0.05$. Results: The prevalence of impacted ST on CBCT was 2.63%. Most impacted ST occurred in permanent dentition (63.2%) and presented as single (73.5%), conical (44.1%), and maxillary (69.2%) teeth. Clinical outcomes were observed in 73.5% of patients. Dentition stage was significantly associated with clinical outcome ($\chi^2 = 4.253$, $p = 0.039$), and logistic regression identified primary dentition as an independent predictor of clinical outcome (OR = 5.769, 95% CI: 1.346-24.720; $p = 0.018$). Conclusion: Impacted ST demonstrates a substantial complication burden, particularly in primary dentition. CBCT provides comprehensive three-dimensional assessments that support early diagnosis and informed treatment planning.

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1. INTRODUCTION

Supernumerary tooth (ST), commonly known as hyperdontia, is a dental anomaly characterised by the presence of an additional tooth or tooth-like structure beyond the normal series of dentition (He et al., 2023). Reported prevalence ranges from 0.3% to 3.5% and varies according to population, dentition stage, and diagnostic method (Mossaz et al., 2016). The orientation of ST within the dental arch can differ, appearing in vertical, transverse, oblique, or inverted positions (Davidson et al., 2025). Morphologically, ST may exhibit similar characteristics of a normal tooth, referred to as supplemental type, or presented as conical, tuberculate and irregularly shaped (Tworkowski et al., 2020). Crowding, spacing, tooth impaction, and root resorption are among the clinical outcomes as sequelae of ST. In cases involving impacted ST, impacted ST posed a concerning clinical outcome. A previous study reported a high incidence of impacted ST, with 84% incidence in 156 ST cases (Demiriz et al., 2015). A thorough clinical and radiographic examination is required to detect ST (Delilbaşı et al., 2017; Zhu et al., 2022). Thus, understanding supernumerary teeth can enable dentists to make early diagnoses, intervene, and prevent many complications associated with them (Singh et al., 2019).

The aetiology of supernumerary teeth is poorly understood. The most likely theory for the development of hyperdontia is the hyperactivity of the dental lamina (Allison et al., 2020; Chen et al., 2019; Park et al., 2020; Tworkowski et al., 2020). This idea suggests that supernumerary teeth can form from epithelial cells in dental lamina that have not fully reabsorbed. Besides, the formation of a supernumerary tooth can occur due to the dichotomy of the tooth bud (Allison et al., 2020; Gurung et al., 2021; Park et al., 2020). Furthermore, genetics and heredity are considered significant factors in the occurrence of supernumerary teeth, particularly in individuals with a family history or associated syndromes (Allison et al., 2020; He et al., 2023; Tumen et al., 2010). Supernumerary teeth are found in over 50 disorders, highlighting the complexity of the genetic aetiology (Allison et al., 2020). The formation of supernumerary teeth can occur due to maxillofacial anomalies, such as cleft lip, cleft palate, and cleidocranial dysplasia, and in trichorhinophalangeal, Gardner, and Marfan syndromes, which result from DNA mutations of the tooth germ (Chen et al., 2019; Delilbaşı et al., 2017).

The prevalence of supernumerary teeth (ST) in Malaysia varies by region and population. Multiple prevalence studies have been conducted using cone-beam computed tomography (CBCT). A study in Northern Malaysia (University Sains Malaysia) involving 4645 in paediatric patients found an overall prevalence of about 2.0%. Males (4.0%) showed a higher incidence of ST than females (0.8%), with greater involvement in the maxillary arch and mostly affecting patients aged 7 to 12 years (Bahoudela et al., 2022). Another study in Northern Malaysia (AIMST University) reported that 108 of 10,200 patients aged 18 to 35 years were diagnosed with ST. A total of 72 patients had ST in the maxillary region, 24 (22%) in the mandibular region, and only 6 (6%) in both the maxillary and mandibular regions (Singh et al., 2019). Prevalence rates of ST can vary by region. A study conducted at an Orthodontic Specialist Clinic in Sabah (Ministry of Health Malaysia) revealed that 10.32% of orthodontic patients presented with ST, based on pre-treatment orthodontic records (Allison et al., 2020). Hence, the prevalence of ST in Malaysia varies across regions and populations, highlighting the importance of regional and demographic factors in understanding this dental anomaly.

Advancements in imaging technology, such as cone-beam computed tomography (CBCT), have significantly improved the detection and evaluation of ST.CBCT is a specialised imaging technology

widely used in dentistry for its high precision in capturing 3D images of the maxillofacial region (Sukmadewi & Dananjaya, 2023). CBCT was introduced in 1988 and represented a true paradigm shift (Henein et al., 2021). CBCT provides accurate, sub-millimeter-resolution images, providing three-dimensional visualisation of the oral and maxillofacial region (Henein et al., 2021; Nematolahi et al., 2013). CBCT can provide valuable information, such as the position of the tooth relative to key features, including root apices and jaw alignment (Dalessandri et al., 2011; Gurung et al., 2021). It can measure the distance between a supernumerary tooth and the adjacent tooth roots and cortical bone, avoiding errors caused by bone overlap and other factors (Henein et al., 2021). Compared with panoramic imaging, CBCT allows more accurate assessment of tooth position, morphology, orientation, and proximity to adjacent roots and cortical boundaries, without the superimposition inherent to two-dimensional techniques (Gurung et al., 2021; Tumen et al., 2010). Besides, perforation of both buccal and lingual cortical plates cannot be appreciated on the panoramic image, which can only help localize the presence of a complex odontoma. CBCT imaging helps clinicians examine eruption patterns and changes, tooth morphology, location, and its relationship with nearby structures to develop a treatment plan and prognosis due to its high accuracy (Nematolahi et al., 2013; Sukmadewi & Dananjaya, 2023).

Supernumerary teeth can significantly impact dental and overall oral health in various ways, depending on their location, type, and stage of development. Several clinical complications may arise from ST, such as malocclusion, dental caries, delayed tooth eruption, root resorption, cyst formation, and more (Tworkowski et al., 2020). One of the primary concerns is crowding and displacement within the dental arch, which can lead to misalignment of surrounding teeth and necessitate orthodontic intervention to correct malocclusion and spacing issues. Apart from that, the development of dental caries and plaque accumulation results from the patient being unable to clean the crowded side effectively (Kolawole & Folayan, 2019). Additionally, mesiodens is the most common type of ST and is in the maxillary central incisor region (Zhao et al., 2021). Mesiodens may cause delayed or ectopic eruption of permanent teeth, resulting in impacted teeth or abnormal eruption paths that disrupt normal dentition development in children. The presence of an untreated ST, regardless of its eruption status, especially when impacted, can cause several orthodontic discrepancies, such as delayed eruption or retention of adjacent teeth, displacement of the crowns of neighbouring teeth, crowding, spacing, abnormal root formation or root resorption, and so on (Cholavoka & Georgiev, 2024).

Furthermore, these impacted ST are sometimes associated with the development of pathological cysts, such as dentigerous cysts (Lustmann & Bodner, 1988). These can cause bone destruction, swelling, and discomfort, often requiring surgical removal to prevent further complications. Aesthetic and functional issues are also common, particularly when ST are present in the front of the mouth, affecting dental appearance and potentially causing psychological concerns in children and adolescents (Kouri et al., 2014). In severe cases, abnormal tooth alignment can interfere with chewing and speech. Understanding these clinical implications is crucial for effective diagnosis and treatment planning, typically involving a multidisciplinary team that may include orthodontists, oral surgeons, and paediatric dentists.

Despite the recognised clinical relevance of ST, data on their prevalence, radiographic characteristics, and associated clinical outcomes remain limited in Malaysian institutional CBCT cohorts. Therefore, this study aimed to determine the prevalence of impacted ST detected on CBCT at the Faculty of Dentistry, UiTM, to describe their three-dimensional radiographic characteristics, and to evaluate their association with clinical outcomes.

2. MATERIAL AND METHODS

2.1. Sample Selection

This retrospective cross-sectional study was conducted following the approval by UiTM Faculty of Dentistry Ethics Research Committee [Reference No: ERC/01/2025 (ERP/10/19) (39)] at the Diagnostic Imaging Unit, Faculty of Dentistry, Universiti Teknologi Mara (UiTM). The source population consisted of all patients who underwent cone-beam computed tomography (CBCT) imaging at the faculty between 2016 and 2025. Radiographic data was retrieved from the Diagnostic Imaging Unit's imaging database at the Faculty of Dentistry, UiTM Sungai Buloh. A total of 2589 CBCT scans were retrieved from the institutional imaging database. These scans were originally obtained for various diagnostic purposes including implant planning, orthodontic assessment, and evaluation of impacted teeth. Similar retrospective CBCT-based designs have been widely used to investigate the prevalence and characteristics of ST in dental populations (He et al., 2023; Kolarkodi & Alshawy, 2026b) . Sixty-eight patients' CBCT were identified with impacted ST.

2.2. Inclusion And Exclusion Criteria

Patients were included if they had CBCT scans obtained at the UiTM Imaging Unit between 2016 and 2025 and if records indicated the presence of impacted ST. Records with complete clinical and radiographic documentation relevant to ST were also included. Exclusion criteria include patients with previously diagnosed syndromes associated with ST, such as cleft lip and palate or cleidocranial dysplasia, CBCT scans with poor image quality or insufficient resolution for accurate evaluation and imaging records with missing or unclear documentation regarding ST. No CBCT scans were excluded due to image quality, as all obtained scans were diagnostically adequate for review. As a result, the final analysis included all 68 CBCTs.

2.3. Sample size calculation

Sample size estimation was performed in G*Power version 3.1 using a logistic regression model. The parameters specified were an expected odds ratio of 2.33, baseline probability of clinical outcome of 0.30, alpha of 0.05, and power of 0.80. These assumptions were informed by previously reported effect sizes for complications associated with ST (Park et al., 2020). A significance level (α) of 0.05 and a power ($1-\beta$) of 0.95 were chosen to minimize Type I and Type II errors, respectively. The results indicated that a total sample size of 124 participants is required to detect the specified effect.

2.4. CBCT protocol and image evaluation

CBCT examinations had been acquired using CARESTREAM CS 9300 and CS 9000 units (Carestream Dental, USA) and were reviewed using CS 3D Imaging software version 3.8. For regional dentomaxillofacial imaging, a 10 x 5 cm field-of-view protocol was typically used, with voxel size 0.18-0.20 mm, tube voltage 90 kVp, tube current 4-10 mA, and exposure time 8-12 s, according to manufacturer-recommended settings for the diagnostic evaluation of impacted teeth and adjacent structures.

The CBCT volumes were evaluated by two researchers on a 27-inch ViewSonic monitor (Model VA2248M-LED; ViewSonic Corp., CA, USA; 1920 x 1020 pixels) in a dimly lit room. Assessment was performed on axial, coronal, and sagittal multiplanar reconstructions. When an impacted ST was identified on a limited field-of-view scan (5 x 3 cm, 5 x 5 cm, or 10 x 5 cm), the finding was cross-checked against the corresponding clinical record in IDERMS, including available conventional radiographs. The workflow for data collection is presented in Figure 1.

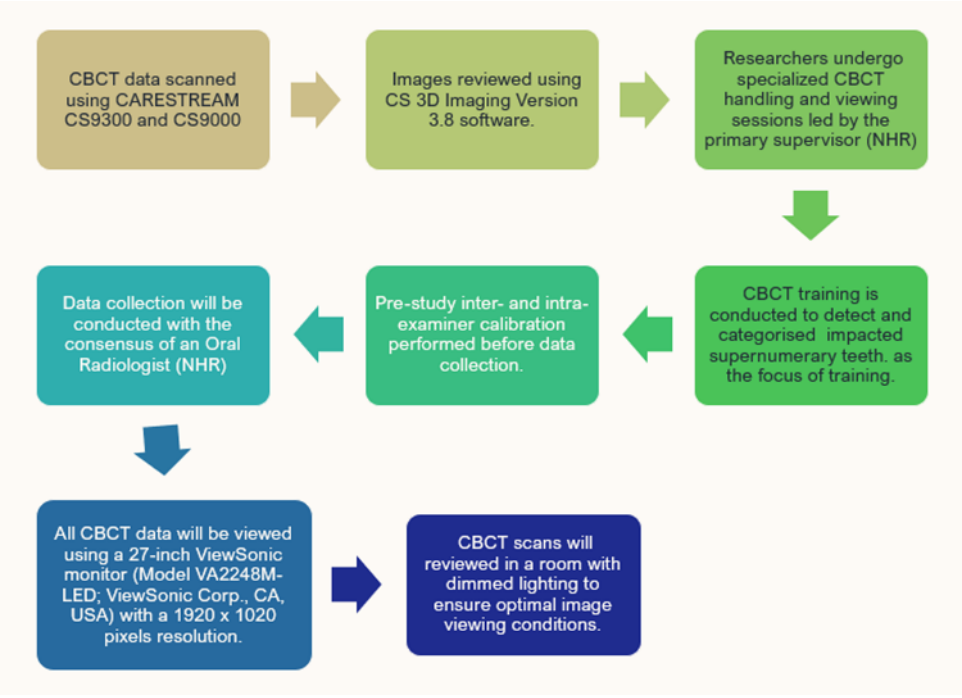


Fig. 1. Cone beam CT data collection workflow.

2.5. Reliability assessment

Before data collection, both researchers underwent calibration training in CBCT volume viewing and interpretation under supervision of an oral and maxillofacial radiologist (NHR), with specific emphasis on the detection and evaluation of impacted ST. For intra-examiner reliability, 20% of randomly selected CBCT scans were re-evaluated after a 2-week interval. For inter-examiner reliability, all 68 CBCT volumes were independently assessed by both researchers. Agreement was analysed in IBM SPSS using Cohen's kappa statistic and interpreted according to the Landis and Koch criteria. Intra- and inter-examiner agreement were $\kappa = 0.89$ and $\kappa = 0.81$, respectively, indicating almost perfect agreement.

2.6. Parameters

Demographic variables, including gender and age for each patient, were obtained from the IDERMS platform. For each confirmed impacted ST, data were recorded in a structured Microsoft Excel spreadsheet, including dentition (primary dentition, early mixed dentition, late mixed dentition, or permanent dentition), position (anterior maxilla, posterior maxilla, anterior mandible, or posterior mandible), shape (conical, supplemental, tuberculate, or atypical) while direction (normal, inverted, horizontal, or oblique), and associated clinical outcomes, including spacing, rotation of adjacent teeth, delayed eruption of adjacent teeth, root displacement or root resorption of adjacent teeth. Demographic variables, including gender and age for each patient, were obtained from the IDERMS platform. For each confirmed impacted ST, data were recorded in a structured Microsoft Excel spreadsheet, including dentition (primary dentition, early mixed dentition, late mixed dentition, or permanent dentition), position (anterior maxilla, posterior maxilla, anterior mandible, or posterior mandible), shape (conical, supplemental, tuberculate, or atypical) while direction (normal, inverted, horizontal, or oblique), and associated clinical outcomes, including spacing, rotation of adjacent teeth, delayed eruption of adjacent teeth, root displacement or root resorption of adjacent teeth.

Shape and orientation definitions were applied consistently with reference to a previous study: as shown in Figure 2, conical teeth were small/peg-shaped with normal roots; supplemental-shaped teeth were duplications of teeth in the normal series; tuberculate teeth were barrel-shaped, with more than one cusp and atypical morphology with no regular shape (Park et al., 2020). In orientation, normal or vertical teeth had their long axis parallel to neighboring teeth, inverted teeth had crowns directed opposite to the normal orientation, horizontal teeth were nearly perpendicular to the normal tooth axis, and oblique teeth lay between vertical and horizontal alignment (Kolarkodi & Alshawy, 2026a) (Figure 3).



Fig. 2. CBCT 3D volume rendering images showing different morphological shapes of supernumerary teeth. (a) Conical. (b) Supplemental. (c) Tuberculate.

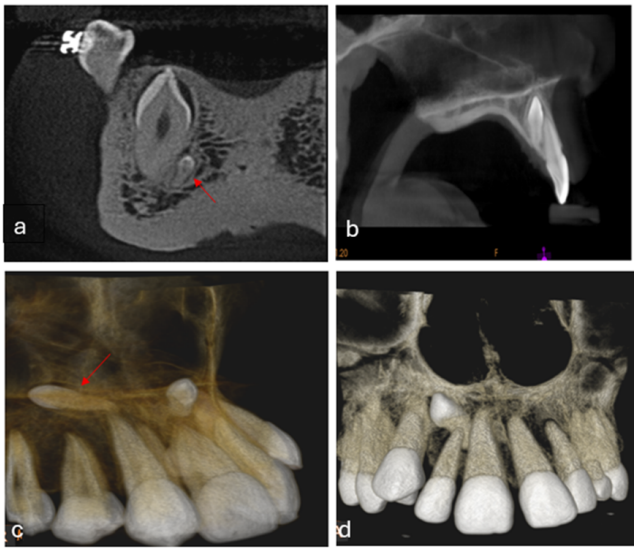


Fig. 3. CBCT images demonstrate different directions of supernumerary teeth. (a) Vertical direction. (b) Inverted direction. (c) Horizontal direction. (d) Oblique direction. The red arrow points to the ST in the CBCT images.

2.7. Statistical Analysis

Statistical analyses were performed using IBM SPSS Statistics version 29. Descriptive statistics were used to summarise demographic and radiographic characteristics. Categorical variables were presented as frequencies and percentages, whereas continuous variables, including age and number of ST per patient, were summarised using means and standard deviations. Associations between study variables and clinical outcome were assessed using the chi-square test. Binary logistic regression was then performed with clinical outcome (presence versus absence of any complication) as the dependent variable to identify independent predictors. Statistical significance was set at $p < 0.05$.

2.8. Analytical grouping strategy

For bivariate analysis, several variables were dichotomised to ensure adequate cell counts and to satisfy chi-square assumptions. Age was grouped as <=18 years and >=19 years. Dentition stage was recoded as primary/mixed dentition versus permanent dentition. Shape was grouped as conical versus non-conical. Direction was grouped as vertical (normal and inverted) versus non-vertical (horizontal and oblique). Position was simplified to maxilla versus mandible for inferential analysis.

3. RESULTS

Among the 2,589 CBCT examinations reviewed, 68 patients had impacted ST, yielding a prevalence of 2.63%. The study population ranged from five to sixty-nine years old patient, with the mean age of 17.1 years. Most cases occurred in patients aged <=18 years (63.2%), while 36.8% occurred in those aged >=19 years (Figure 4). There were 39 male patients (57.4%) and 29 female patients (42.7%), corresponding to a male-to-female ratio of 1.34:1 (Figure 5).

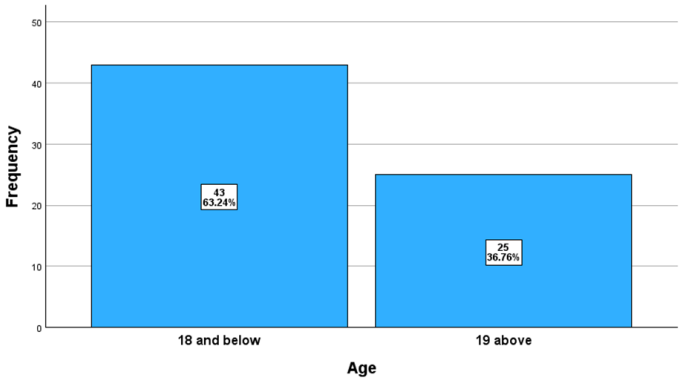


Fig. 4. Distribution of supernumerary teeth according to age (n = 68). 18 and below was the most prevalent (n = 43), followed by 19 above (n=25).

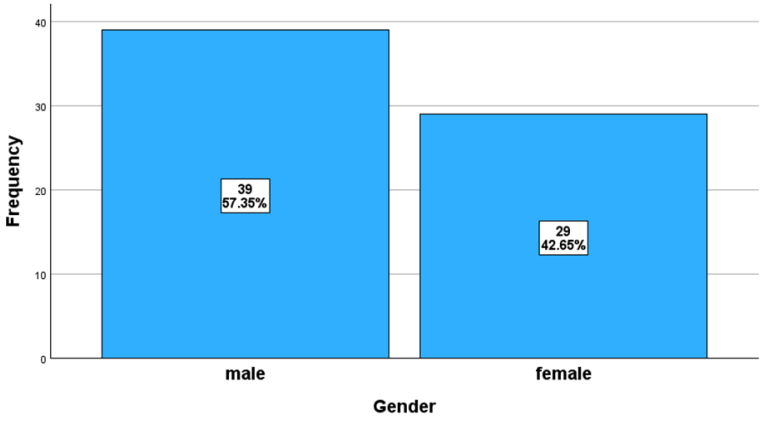


Fig. 5. Distribution of supernumerary teeth according to gender (n = 68). Majority was male (n=39) and female was (n=29).

The average number of ST per patient was 1.26. Single ST was found in 50 patients (73.5%), whereas 18 patients (26.5%) had two or more STs (Figure 6). The majority of ST were observed in permanent dentition (63.2%) (Figure 7).

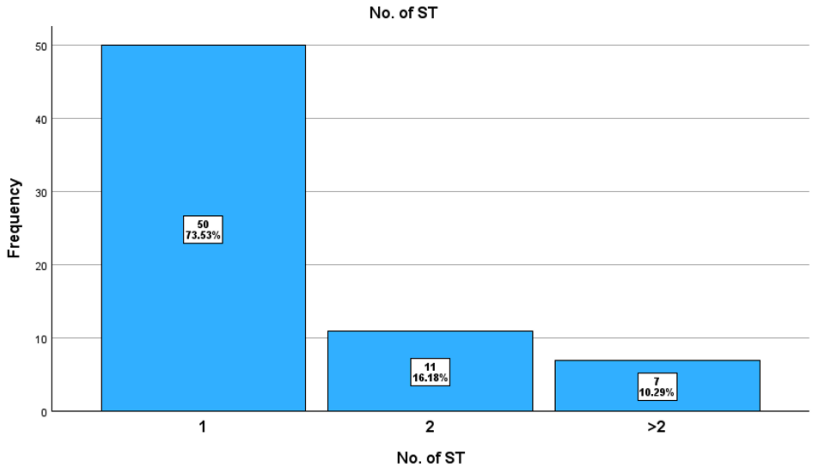


Fig. 6. Distribution according to the number of supernumerary teeth (n = 68). Single ST was the most prevalent (n = 50), followed by 2 STs (n=11) and more than 2 STs (n=7).

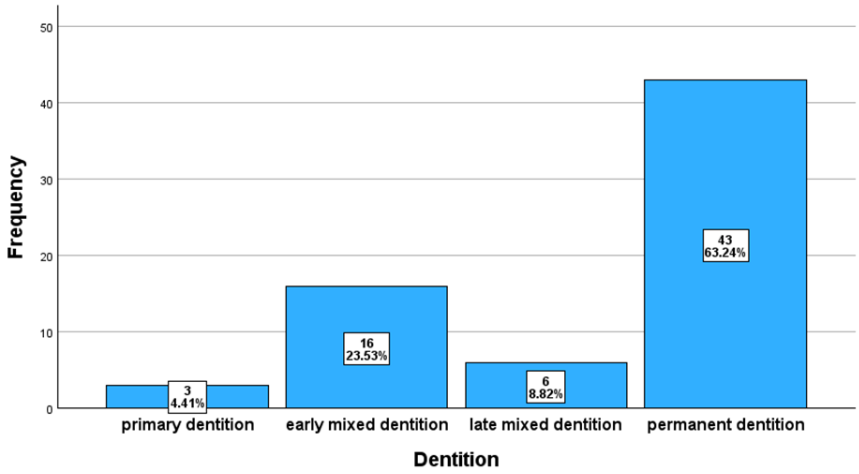


Fig. 7. Distribution of supernumerary teeth according to dentition stage (n=68). Permanent dentition was the most prevalent (n = 43), followed by early mixed dentition (n = 16), late mixed dentition (n = 6), and primary dentition (n = 3).

Conical (44.1%) was the most common morphological type of ST, followed by supplemental (30.9%), tuberculate (19.1%) and atypical (5.9%) (Figure 8).

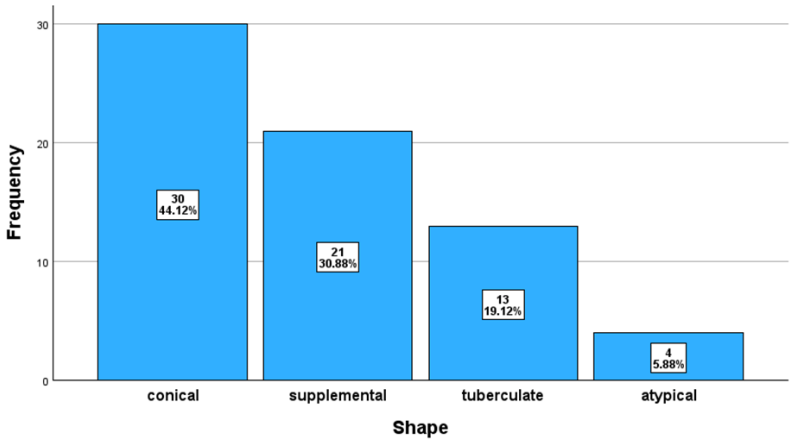


Fig. 8. Distribution of supernumerary teeth according to morphological shape (n = 68). Conical morphology was the most prevalent (n = 30), followed by supplemental (n = 21), tuberculate (n = 13), and atypical forms (n = 4).

The highest proportion of ST was in the anterior maxilla (57.4%), followed by the posterior mandible (22.1%), the posterior maxilla (11.8%), and the anterior mandible (8.8%) (Figure 9). An example of ST located in the anterior maxilla is demonstrated in Figure 10.

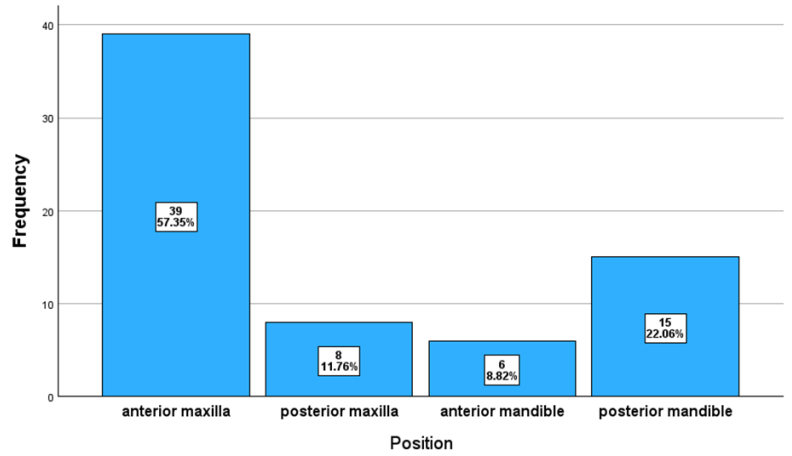


Fig. 9. Distribution of supernumerary teeth according to position (n=68). Majority STs located at the anterior maxilla (n=39), followed by posterior mandible (n=15), posterior maxilla (n=8) and anterior mandible (n=6).

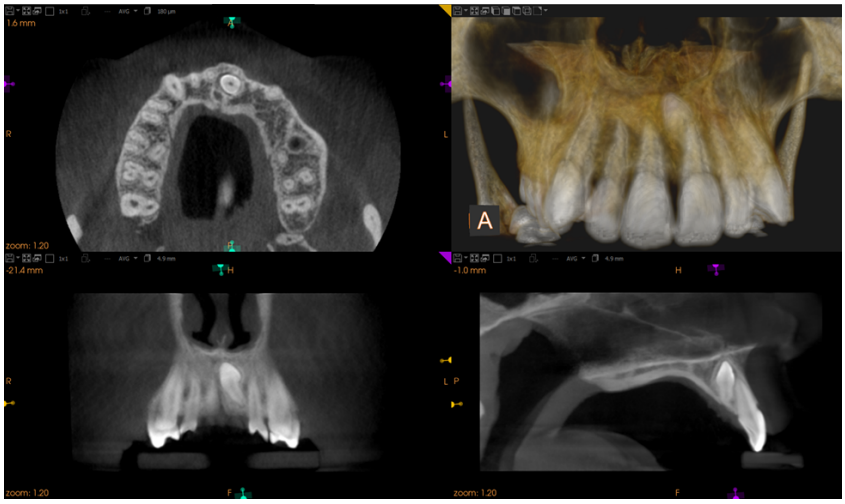


Fig. 10. CBCT images demonstrate an impacted supernumerary tooth in the anterior maxilla. (a) Axial view showing the presence of a supernumerary tooth located palatal to the maxillary anterior teeth. (b) Three-dimensional reconstructed view illustrating the spatial relationship of the supernumerary tooth to the adjacent maxillary incisors. (c) Coronal view demonstrating the inverted position of the impacted supernumerary tooth within the anterior maxilla. (d) Sagittal view showing the orientation and inclination of the impacted supernumerary tooth relative to the maxillary alveolar bone.

Regarding the direction of ST, 29.4% were positioned inverted, while 14.7% were horizontal. Both normal and oblique shared the same results (27.9%) (Figure 11).

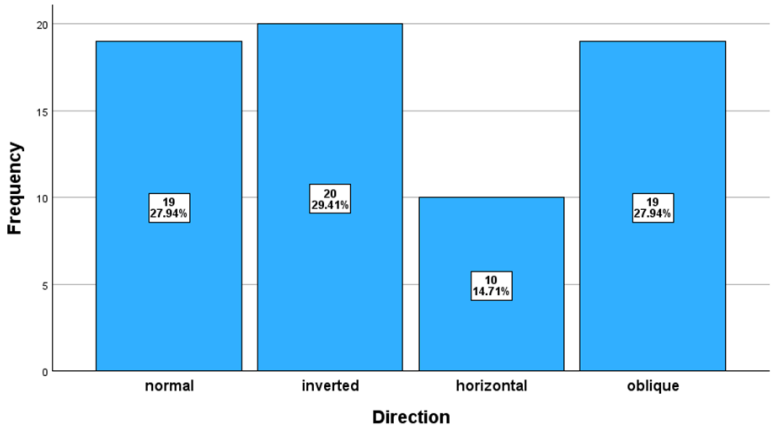


Fig. 11. Distribution of supernumerary teeth according to direction (n=68). Inverted was the most prevalent (n = 20), followed by normal and oblique (n = 19), and horizontal (n=10).

Figure 12 shows examples of complications associated with ST including rotation, root resorption, root displacement, and delayed eruption of adjacent teeth. Among 68 STs found on CBCT images, 50 (73.6%) were associated with complications, whereas 18 patients had none. The most common complication was root displacement of adjacent teeth (41.2%), followed by rotation of adjacent teeth (11.8%) and delayed eruption of adjacent teeth (10.3%) (Figure 13).

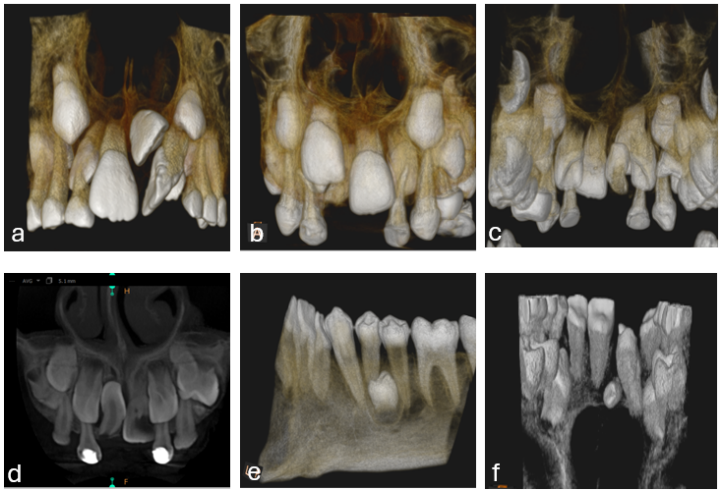


Fig. 12. CBCT images demonstrating clinical outcomes associated with impacted supernumerary teeth. (a) Three-dimensional reconstructed anterior view showing displacement of the maxillary anterior teeth due to the presence of supernumerary teeth. (b,c,d) Three-dimensional reconstructed view illustrating delayed eruption of maxillary central incisors due to presence of impacted supernumerary teeth. (e) Three-dimensional reconstruction of the mandibular region showing an impacted supernumerary tooth causing root resorption of its adjacent tooth. (f) Three-dimensional reconstruction showing an impacted supernumerary tooth causing root displacement of adjacent tooth.

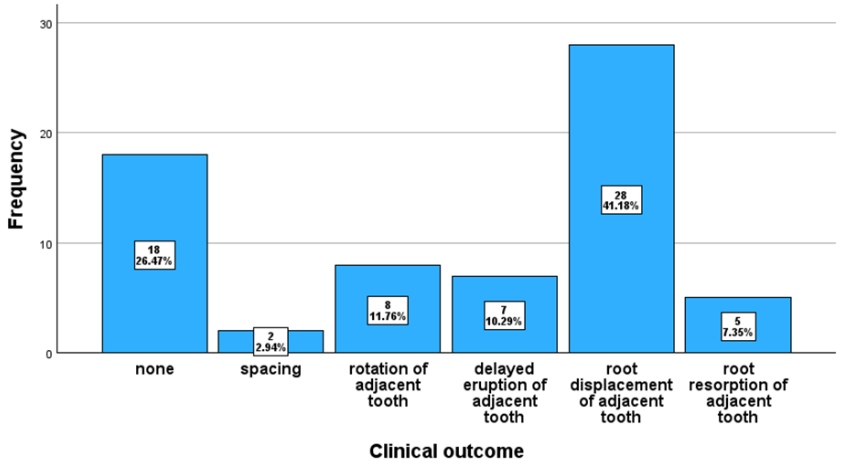


Fig. 13. Distribution of supernumerary teeth according to clinical outcome (n=68). The most common complication was root displacement of adjacent tooth (n=28), followed by rotation of adjacent tooth (n=8) and delayed eruption of adjacent tooth (n=7), root resorption of adjacent tooth (n=5) and spacing (n=2). Supernumerary teeth without complication accounted for 18 cases (n=18).

The associations between age, gender, number of STs, dentition, shape, position, and direction and the clinical outcomes were recorded in Table 1. Only dentition type showed a statistically significant correlation with clinical outcome among the variables examined ($p = 0.039$), with a higher proportion of clinical outcomes in primary dentition than in permanent dentition. Clinical outcomes were not significantly correlated with age, gender, number of ST morphology, position, or orientation ($p > 0.05$).

Logistic regression analysis, as shown in Table 2, confirmed that primary dentition was an independent predictor of dental outcomes. Compared to patients in the permanent dentition group, patients in the primary dentition group were more likely to experience clinical outcomes (OR = 5.769, 95% CI: 1.346–24.720, p = 0.018). No other radiographic characteristic demonstrated a significant independent association.

Table 1. Bivariate Analysis by each study variable according to the absence or presence of the clinical outcome.

		Clinical outcome				χ^2	P value
		No		Yes			
		n (%)		n (%)			
Age	18 and below	11	25.6	32	74.4	0.048	0.827
	Above 19	7	28.0	18	72.0		
Gender	Male	12	30.8	27	69.2	0.868	0.351
	Female	6	20.7	23	79.3		
No of ST	1	14	28.0	36	72.0	0.227	0.634
	>1	4	22.2	14	77.8		
Dentition	Permanent dentition	15	34.9	28	65.1	4.253	**0.039***
	Primary dentition	3	12.0	22	88.0		
Shape	Conical	9	30.0	21	70.0	0.344	0.558
	Non conical	9	23.7	29	76.3		
Position	Maxilla	14	29.8	33	70.2	0.860	0.354
	Mandible	4	19.0	17	81.0		
Direction	Vertical	7	36.8	12	63.2	1.457	0 .227
	Others	11	22.4	38	77.6		

*Statistical significance (P≤0.05).

Table 2. Logistic Regression of Variables Associated with Clinical Outcome.

Variable		OR	95% CI	P value
Dentition	Permanent (Reference)	-	-	-
	Primary	5.769	1.346-24.720	**0.018***
Shape	Conical (Reference)	-	-	-
	Non-conical	1.075	0.306-3.778	0.910
Position	Maxilla (Reference)	-	-	-
	Mandible	3.950	0.870-17.933	0.075
Direction	Vertical (Reference)	-	-	-
	Others	2.404	0.664-8.695	0.181

OR=odds ratio; CI=confidence interval; *Statistical significant (P≤0.05).

4. DISCUSSION

The present study investigated the prevalence and radiographic characteristics of impacted ST using CBCT imaging in an institutional dental population. The overall prevalence of 2.63% observed in this study is consistent with previously reported prevalence ranges of 0.3% to 3.8% in non-syndromic populations (He et al., 2023; Mossaz et al., 2016). The differences in prevalence can be explained by variations in study design, imaging techniques, and the demographic traits of the populations studied. Additionally, CBCT studies reported higher prevalence compared to conventional dental imaging due to the accuracy of the image presented in multiple planes (Gurung et al., 2021).

In this study, 63.2% of cases were found in patients aged 18 and below consistent with previous studies that reported ST in the mixed dentition stage (He et al., 2023; Kolarkodi & Alshawy, 2026b). This could be attributed to urgent clinical issues related to the appearance of maxillary incisors and the prompt emergence of ST-related complications, including delayed eruption. (He et al., 2023). While a recent study utilised a broader age-stratified approach, the finding that 63.2% of cases occur in patients aged 18 and below aligns with their observation that the majority of ST are diagnosed and managed during the early to late mixed-dentition stages. Furthermore, He et al. noted that the incidence of ST declined gradually with age among patients aged 7-12 (He et al., 2023). The extraction of erupted ST or ST with problems during the early dentition stage could be the cause. However, recent institutional findings suggest that if an impacted supernumerary tooth is present, the likelihood of a complication remains consistently high regardless of the patient's age. Bivariate Analysis showed that 74.4% of patients aged 18 and below presented with a clinical outcome, while 72.5% of patients aged 19 and above did. While He et al. suggest that remaining ST in older cohorts is often uncomplicated or buried, recent institutional findings indicate that adult cases are as likely to exhibit clinical complications as pediatric ones. This lack of statistical significance (P = 0.827) challenges the assumption that adult impactions are inherently more quiescent. Early diagnosis is particularly important because supernumerary teeth may interfere with the eruption pathway of adjacent permanent teeth, resulting in delayed eruption or ectopic positioning (Park et al., 2020).

A male predominance was observed in this study with a male-to-female ratio of 1.34:1. This finding aligned with multiple epidemiological studies reporting a higher prevalence based in male (Katanaki et al., 2025; Singh et al., 2019). A similar male predominance has been reported by Goswami S. (male–to-female ratio: 1.28:1), Singh et al. (1.3:1), Katanaki, N. et al. (2:1), and He et al. (2.7:1) (He et al., 2023; Katanaki et al., 2025; Singh et al., 2019; Suchetana, 2023). It has been suggested that the male predominance may be due to a sex-linked inheritance pattern (Suchetana, 2023).

In this study, 73.5% of impacted ST was recorded with 16.2% had 2 ST, and 10.3% had 3 or more ST. In the previous study by He et al., the number of ST ranged from 1 to 4 with the most common ST is a single supernumerary tooth (68.2%), followed by 2 ST (31.2%), 3 ST (0.3%), and 4 ST (0.2%) (He et al., 2023). Multiple STs (≥ 5) are uncommon and are usually associated with a syndrome, such as cleidocranial dysplasia (Hamada et al., 2021). According to a similar study by Bereket, the results suggested that 77.4% of patients had 1 supernumerary tooth, 18.4% had 2 ST, and 4.2% had 3 or more ST (Bereket et al., 2015).. Based on the bivariate analysis, 72% of patients with a single ST presented with a clinical outcome, and 77.8% with multiple STs. The analysis yielded a P-value of 0.634, indicating no statistically significant association between the number of ST and the occurrence of clinical outcomes. This finding suggests that the mere presence of even a single supernumerary tooth carries a high pathological potential, nearly equal to that of multiple impactions.

In the present study, the prevalence of ST was higher in permanent than in primary dentition, consistent with the findings of studies by Katanaki, N. et al., and Goswami S. (Katanaki et al., 2025; Suchetana, 2023). However, primary dentition demonstrated a significant association with clinical outcome ($\chi^2 = 4.253$, $p = 0.039$). Clinical complications occurred more frequently in primary dentition (88%) than in permanent dentition (65.1%). Logistic regression analysis further confirmed primary dentition as an independent predictor of clinical outcome. ST occurring in primary dentition were approximately 5.8 times more likely to be associated with clinical outcomes compared to those in permanent dentition (OR = 5.769, 95% CI: 1.346–24.720, $p = 0.018$) after an adjustment has been made for shape, position, and direction. The wide confidence intervals observed in this study may reflect the relatively small sample size, potentially affecting the accuracy of the estimated odds ratios. Park et al. found that clinical outcomes, such as rotation and delayed eruption of adjacent teeth, were considerably higher in primary and early mixed dentition compared to permanent dentition ($P < 0.05$) (Park et al., 2020). It may be due to ST having a greater influence on adjacent teeth as deciduous or permanent teeth erupt. In contrast, with completed root formation, tooth positions in permanent dentition are more stable, potentially minimizing the visible impact of ST.

In this study, 57.4% of STs were in the anterior maxilla, 11.8% in the posterior maxilla, 8.8% in the anterior mandible, and 22.1% in the posterior mandible. A previous study by He et al. also shows that ST most commonly presents in the anterior maxillary region, accounting for 91.3% of patients, followed by the mandibular posterior region, the second most common region (He et al., 2023). Bivariate Analysis was conducted between the maxillary and mandibular regions, and it showed that 70.2% of patients with maxillary ST presented with a clinical outcome, while 81% of patients with mandibular ST did. However, the P-value is 0.354, indicating no statistically significant association between ST position and clinical outcomes. Logistic regression was further conducted using the maxilla as the reference group to investigate the impact of anatomical location on clinical outcome. The analysis showed an odds ratio of 3.950 for the mandible. Hence, this suggests that ST in the mandible are nearly four times more likely to be associated with clinical outcomes than those in the maxilla. However, with a P-value of 0.075 and a wide 95% confidence interval (0.870-17.933), this remains a statistical trend rather than a significant finding. The P-

value is approaching significance in the regression model (P = 0.075), suggesting that the mandible's anatomical environment may confer a higher relative risk of mechanical obstruction or pathological changes. Therefore, while the maxilla accounts for the greater volume of cases at UiTM, mandibular impactions should be approached with high surgical suspicion and detailed CBCT mapping to mitigate their potentially greater risk of morbidity.

A previous study reported conical supernumeraries (65.3%) were the most common among the other types, such as tuberculate, supplemental and atypical (Suchetana, 2023). A recent study is very supportive of this distribution, demonstrating a high proportion of conical morphology (44.1%), followed by supplemental (30.9%). This data is consistent with earlier literature by Kolarkodi et al., Park et al., and Deepa Gurung et al., who all reported conical as the predominant shape (Gurung et al., 2021; Kolarkodi & Alshawy, 2026a; Park et al., 2020). In bivariate analysis, shape was not associated with clinical outcomes ($\chi^2 = 0.344$, $p = 0.558$), with complications present in 70% of conical cases and 76% of non-conical cases. On the other hand, logistic regression showed that non-conical ST had slightly higher odds of complications than conical ST but was not an independent predictor of dental outcomes. This is aligned with a previous study: the complications associated with tuberculate (non-conical) morphology were as high as 69%, and a tuberculate ST is 0.1 to 2 times more likely to cause rotation and spacing issues among adjacent teeth than a conical ST (Gurung et al., 2021).

A previous study done by He et al. found that the most common orientation of ST is normal (320 teeth), followed by inverted (275 teeth), palatal transverse (138 teeth), undefined (61 teeth), labial transverse (16 teeth), mesial horizontal (10 teeth) and distal horizontal (5 teeth) (He et al., 2023). In this recent study, 27.9% of STs are in a normal orientation, 29.4% are inverted, 14.7% are horizontal, and 27.9% are oblique. Bivariate Analysis was conducted with normal orientation, and inverted was grouped into "vertical" orientation, while horizontal and oblique were grouped into "others". The result demonstrates that vertical ST is the most common orientation, which aligns with the previous study by He et al. However, non-vertical directions are more frequently associated with clinical morbidities than vertical orientation. In this recent study, in which the ST was oriented vertically, 63.2% (12 out of 19 cases) were associated with clinical outcomes, such as impaction of neighboring teeth or displacement. For teeth with non-vertical directions, the complication rate rose to 77.6% (38 out of 49 cases). The Chi-square test yielded a P-value of 0.227 ($\chi^2 = 1.457$), indicating that the direction of the ST is not a statistically significant predictor of clinical outcomes in this cohort. To delve deeper into the relative risk, the logistic regression model used the "Vertical" orientation as the reference group. The analysis yielded an OR of 2.404 for "Others." This suggests that ST with non-vertical orientations are 2.4 times more likely to result in clinical outcomes than those in a vertical position. However, with a P-value of 0.181 and a 95% confidence interval of 0.664–8.695, this increased risk does not reach statistical significance in this model.

In this study, 73.5% of patients with affected ST had clinical outcomes, suggesting a high incidence of complications. The most frequent issue was root displacement of adjacent teeth (41.2%), which was followed by rotation and delayed eruption of adjacent teeth (11.8% and 10.3%, respectively). This could be suggested when the unerupted supernumerary tooth physically presses against the roots of permanent teeth, causing displacement, rotation, or angulation. However, fewer studies have specifically described root displacement of adjacent teeth as a clinical outcome in CBCT-based evaluations of ST; instead, they have focused more on spacing and delayed eruption. Different study populations, age distributions, and diagnostic criteria for determining clinical outcomes may all affect the incidence of various complications.

It could be suggested that CBCT imaging facilitated precise evaluation of the clinical outcome of ST, as it provides a three-dimensional view that allows detection of various problems, including root displacement (Ballikaya et al., 2022). Besides, spacing or median diastema was reported as the most common complication in one study (Gurung et al., 2021). Among all the variables, only dentition is correlated with the clinical outcomes. These findings differ from previous studies, which have reported multiple variables statistically significant for clinical outcomes (Ballikaya et al., 2022; Park et al., 2020).

5. CONCLUSION

In this institutional CBCT cohort, impacted ST had a prevalence of 2.63% and were most commonly observed as single, conical anomaly in the maxilla. Clinical outcomes were present in most patients, and dentition stage was the only significant predictor of complication. Root displacement was the most prevalent complication affecting adjacent teeth, followed by rotation and delayed eruption. Complications were most pronounced in the combined primary and mixed-dentition group, in which 88.0% of patients were affected, compared with 65.1% of those with permanent dentition. These findings support the value of CBCT for characterising impacted supernumerary teeth and assisting treatment planning, particularly in younger patients with developing dentitions.

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8. CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

9. AUTHORS' CONTRIBUTIONS

Nor Hidayah Reduwan conceptualized and designed the study, supervised the ERP project as the main supervisor, performed the data analysis, drafted and critically revised the manuscript, and served as the first and corresponding author. **Nawwal Alwani Mohd Radzi** contributed to the study design, co-supervised the project, and contributed to the drafting and critical revision of the manuscript**. Siti Nabilah Aisyah Sanadi and Shirley Sangan Anak Jantai** contributed to data collection and data analysis. All authors reviewed and approved the final version of the manuscript.

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11. APPENDIX

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