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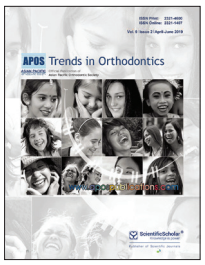

Orginal Article

Orthodontic traction of impacted teeth involving gold chain bonding: A retrospective study on success rate and associated factors

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ABSTRACT

Objectives: This study aims to investigate the success rate of orthodontic traction of impacted teeth using the gold chain bonding (GCB) procedure.

Material and Methods: Orthodontic patients underwent the GCB procedure at the National Dental Centre Singapore (NDCS) between 2014 and 2021. The sample comprised 495 teeth from 421 patients (238 male, 257 female; median age 14; range 7 -38 years). The historical records of these patients' orthopantomograms and electronic medical records were reviewed to collect data on age, gender, ethnicity, tooth type, and surgical re-intervention. The success rate was calculated and compared using chi-square test and logistic regression analysis. The level of significance was set at $P < 0.05$.

Results: The overall success rate of the GCB procedure was 93.3%. There was no significant difference in the success rates between male (92.9%) and female (93.8%) patients ($P = 0.779$) or between Chinese (93.2%), Malay (94.4%), and Indian (91.7%) patients ($P = 0.664$). Younger patients have significantly higher odds of success than older patients ($P = 0.0099$, odds ratio = 0.897). The success rate was highest for the upper lateral incisors (97.4%) followed by upper central incisors (94.7%). The success rate of surgical re-intervention of the GCB procedure was 69%.

Conclusion: Gold chain bonding is a highly predictable procedure for orthodontic treatment of impacted teeth with a high success rate especially in younger patients. Gender and ethnicity do not significantly affect the success rate.

Keywords: Impacted teeth, Gold chain bonding, Orthodontic traction, Success rate, Closed traction, Eruption

INTRODUCTION

Impacted teeth are a common problem in orthodontics that requires careful diagnosis and treatment planning. The aim of this study was to evaluate the success rate of orthodontic traction of impacted teeth using a gold chain bonding (GCB) surgical procedure and to examine the factors that influence the outcome.

An impacted tooth is defined as one in which there is a cessation of eruption caused by clinically or radiographically detectable physical barriers in the eruption path or due to an abnormal eruption of the tooth.[1,2] Other authors define it as one in which the path of eruption is obstructed by an

adjacent tooth or tissue.[3,4] The most frequently impacted teeth are the mandibular third molars and maxillary canines. Other less frequently impacted teeth include the maxillary central incisors, mandibular canines, and premolars.[5] A previous study conducted at our center found that mandibular second molars and maxillary canines had the highest prevalence of impaction, while impaction of the mandibular canines and incisors was rare.[6]

Etiologic factors of impaction include generalized factors such as endocrine deficiencies or febrile illnesses but are more commonly due to localized factors such as tooth size arch length discrepancy, ectopic position of the tooth germ, prolonged retention of the primary tooth, trauma, dilaceration, presence of hard- and soft-tissue pathology, or genetic factors.[7]

As part of a comprehensive orthodontic treatment plan, the GCB surgical procedure is often used to facilitate orthodontic traction of the impacted tooth into the oral cavity. However, this treatment option is not without risks and complications, such as infection, inflammation, root resorption, ankylosis, or failure of traction. Therefore, case selection is important to minimize the failure rate and optimize the outcome.

There are multiple factors to consider when evaluating the prognosis of an impacted tooth for traction. Patient factors include medical history, age, and compliance. Dental factors to be evaluated include the position of the tooth, its root development, and form, as well as the presence of obstruction.

With regard to patient factors, the patient's ability to cooperate and comply for prolonged treatment must be evaluated. Age is a significant factor that influences the success of impacted tooth traction.[8-10] Becker and Chaushu (2003) showed that the prognosis of successful orthodontic resolution of an impacted canine in an adult patient is significantly lower than that in a younger patient, and the prognosis worsens with age. When such treatment is undertaken, successful completion is expected to take considerably longer.[11]

For dental factors, the tooth position can be assessed through the mesial-distal position of its crown, mesial-distal position of its apex, the vertical distance away from the occlusal plane, as well as its angulation to the occlusal plane.[12,13] Root form anomalies, such as the presence of dilaceration, may also complicate the successful traction of the tooth.[14]

This study aims to evaluate the success rate of orthodontic traction of impacted teeth using the GCB procedure and to examine the factors that influence the outcome.

MATERIAL AND METHODS

Orthodontic patients who underwent the GCB procedure at the National Dental Center Singapore (NDCS) between January 1, 2014, and December 31, 2021, were included in this study. All patients who underwent this surgical procedure in NDCS had pre-operative orthopantomograms (OPGs) stored digitally in the hospital's electronic system and electronic medical records as part of standard clinical procedures.

The exclusion criteria were as follows:

(1) Absence of clear pre-operative OPG
(2) Lack of clear documentation to determine success or failure
(3) Lack of orthodontic traction with fixed orthodontic appliance
(4) Lost to orthodontic follow-up before eruption and
(5) Patients with congenital craniofacial syndromes (e.g., cleft lip and palate anomalies)

A research team member was designated to collect the samples from the database. Each tooth was classified as a single case. Electronic medical records were accessed to determine whether the impacted tooth had successfully erupted to its functional position. Success is defined by documentation or radiographic evidence of the eruption of the impacted tooth into a functional position within the oral cavity. Failure was defined as the non-eruption of the impacted tooth.

Descriptive statistics were used to classify the types of teeth that underwent GCB and identify the success rate of orthodontic traction of impacted teeth using GCB. The overall success rate was calculated by the total number of teeth successfully erupted (X) divided by the total number of teeth that had GCB carried out from 2014 to 2021 (Y) X 100%. Baseline demographics and clinical features were compared between the two groups (success vs. failure) using a two-sample *t*-test or Mann–Whitney U-test (depending on normality assumption) and Chi-square or Fisher's exact test (where appropriate) for continuous and categorical variables. The association of baseline characteristics and success rate was investigated using univariate logistic regression analysis, and results were reported as odds ratio (OR) and 95% confidence interval. Significance level was set at $P < 0.05$. Data analysis was performed using Statistical Analysis System software (version 9.4 for Windows).

RESULTS

A total of 530 patients with 616 impacted teeth underwent the GCB procedure between January 1, 2014, and December 30, 2021. However, 121 cases were excluded from the study due to a lack of orthodontic traction with fixed orthodontic appliances or a lack of adequate documentation. Following the exclusion criteria, a total of 495 impacted teeth from 421 patients were included in the analysis.

Of the 495 impacted teeth, 462 erupted successfully into functional occlusion. The remaining 33 impacted teeth failed

to erupt and were planned for removal. The overall success rate of orthodontic traction following the GCB procedure was 93.3%.

Out of the 462 teeth that were successfully tracked, 87 cases underwent surgical re-intervention. Of the 87 re-intervention cases, 52 (67.5%) of cases succeeded in the first re-intervention surgery. Ten cases (11.5%) required a second re-intervention surgery,and eight of these cases resulted in a successful outcome. Overall, 60 of the 87 re-intervention cases were successful. This reflects an overall re-intervention success rate of 69%.

The median age of the sampled population was 14.0 years, with the youngest patient at seven years of age and the oldest at 38 years of age. The age of patients significantly affects the success rate in the univariate logistic regression analysis. Younger patients have higher odds of successful outcomes ($P = 0.0099$, OR = 0.897).

The success rates of different gender and ethnic groups are summarized in [Table 1]. There were 257 females and 238 males included in this study. There was no statistically significant difference ($P = 0.6834$) in the success rates between the male (92.9%) and female (93.8%) groups. With regard to ethnicity, there was also no statistically significant difference ($P = 0.83$) in the success rates among the Chinese (93.2%), Malay (94.4%), and Indian (91.7%) ethnic groups.

[Table 2] summarizes the success rate of different tooth types. The most commonly tracked tooth were maxillary canines (39.0%) followed by maxillary central incisors (31.3%). The least commonly tracked tooth was the maxillary molar (2.0%). The success rate was highest for maxillary lateral incisors (97.4%), followed by the maxillary central incisors (94.2%), maxillary canines (92.7%), and mandibular canines (92.3%). Success rates were lowest for mandibular incisors (83.3%).

[Table 3] summarizes the surgical re-intervention success rate of different tooth types. Teeth that surgical re-intervention was most attempted on were the maxillary canines (40.2%) followed by maxillary central incisors (29.9%).

DISCUSSION

This study intends to investigate the success rate of orthodontic traction in impacted teeth following the GCB procedure.

Results showed that there was an overall success rate of 93.3%. This is a higher success rate when compared to other studies. A systematic review of orthodontic traction of impacted teeth showed a lower success rate of 70% in patients between 20 and 47 years of age.[11] The younger median age of the patients in this study may explain the higher success rate.

The relatively high success rate of 93.3% also indicates that the traction of impacted teeth can be a predictable treatment option. In comparison to the GCB procedure, another treatment alternative of autotransplantation of canines has a lower reported success rate of 38%–74%.

This study found that gender and ethnicity should not affect the clinical decision of whether to attempt the GCB procedure. The finding that younger patients have a higher success rate is consistent with the previous studies.[11] This supports early detection of impaction and early indication of GCB procedure.

Surgical re-intervention was attempted in 17.5% of the cases and achieved a success rate of 69%. The most common reasons noted in literatures for surgical re-intervention are dislodgement of gold chain, lack of movement, loosening of bracket, or post-operative wound infection.[13,15] In comparison, a study on impacted maxillary canines noted that 12% of the GCB cases required re-intervention, achieving a similar success rate of 68%.[13] Taking into consideration the lower success rate and additional risk posed by added surgical procedures, surgical re-intervention should only be attempted after careful considerations. Failure of surgical re-interventions usually results in another surgery to remove the impacted tooth and attachments.

When focusing on maxillary canines, the results of this study found that the success rate of maxillary canine traction was 92.7%. This is lower than the success rate of 96% in a recent study on orthodontic traction of impacted canines in a

Table 1: Success rate of different groups.

Variable	Impacted teeth (*n*)	Percentage (%)	Success (*n*)	Failure (*n*)	Success rate (%)
Gender					
Female	257	52.0	241	16	93.8
Male	238	48.0	221	17	92.9
Ethnic group					
Chinese	381	77.0	355	26	93.2
Malay	54	10.9	51	3	94.4
Indian	48	9.7	44	4	91.7
Others	12	2.4	12	0	100
Total	495	100	462	33	93.3

Table 2: Success rate of different tooth type.

Tooth type	Impacted teeth (*n*)	Percentage (%)	Success (*n*)	Failure (*n*)	Success rate (%)
Maxillary central incisors	155	31.3	146	9	94.2
Maxillary lateral incisors	39	7.9	38	1	97.4
Maxillary canines	193	39.0	179	14	92.7
Maxillary premolars	20	4.0	19	1	95.0
Maxillary molars	10	2.0	9	1	90.0
Mandibular incisors	6	1.2	5	1	83.3
Mandibular canines	26	5.3	24	2	92.3
Mandibular premolars	14	2.8	13	1	92.9
Mandibular molars	32	6.5	29	3	90.6
Total	495	100	462	33	93.3

Table 3: Success rate of surgical re-intervention.

Tooth type	Impacted teeth (*n*)	Percentage (%)	Success (*n*)	Failure (*n*)	Success rate (%)
Maxillary central incisors	26	29.9	20	6	76.9
Maxillary lateral incisors	2	2.3	2	0	100.0
Maxillary canines	35	40.2	23	12	65.7
Maxillary premolars	2	2.3	1	1	50.0
Maxillary molars	2	2.3	1	1	50.0
Mandibular incisors	1	1.1	0	1	0.0
Mandibular canines	7	8.0	4	3	57.1
Mandibular premolars	2	2.3	2	0	100.0
Mandibular molars	10	11.5	7	3	70.0
Total	87	100	60	27	69.0

Poland population.[16] Another study on orthodontic traction of impacted maxillary canines in a Netherlands population also reported a higher success rate of 96%.[13] Variations in clinical protocols when indicating GCB in complex cases may result in a range of success rates at different centers.

This study revealed that the success rate of mandibular canine traction was 92.3%. This was much higher than the success rates found in a systematic review studying orthodontic traction of impacted and transmigrant mandibular canines, which found a success rate of only 17%.[17] The higher failure rate noted in that systematic review may be attributed to the focus on ectopic or transposition of canines that were associated with a higher risk of failure.

The success rate of maxillary central incisors was found to be 94.2%. This is higher than the success rate of 90.0% found in a study that examined impacted maxillary central incisors that underwent a combined orthodontic-surgical approach with similar selection criteria.[18]

The most frequently tracked tooth in this study was found to be the maxillary canines (39.0%) followed by the maxillary central incisors (31.3%). As the most commonly impacted tooth reported is the maxillary canine (Chu *et al*., 2003),[3] it is expected that this tooth should be the most frequently tracked tooth, concurring with the results of our study. With regard to the maxillary central incisor being the second most frequently tracked tooth, it is a tooth that is critical for facial and smile esthetics. Due to the difficulty in camouflaging maxillary lateral incisors as central incisors, the loss of maxillary central incisors often results in the need for prosthetic replacement or compromised esthetic symmetry. The attempt of orthodontic traction of the maxillary central incisor is thus often attempted. On the other hand, impacted premolars and mandibular incisors can frequently be removed with orthodontic space closure achieved in Asian ethnic populations with crowding. This may explain the lower number of patients presented in this study.

The main limitation of this study is the retrospective nature of the study design. As a result, some patients were excluded due to a lack of documentation determining success or failure or were lost to follow-up. This may be a potential source of error and bias.

Future research can focus on the association of dental factors and success rate and formulate a risk assessment tool that can assist clinicians in treatment planning and communication with patients. Clinicians can then be empowered to conduct a risk-benefit analysis to accurately determine the prognosis of the impacted tooth. This would facilitate optimal case selection for orthodontic traction to potentially enhance treatment outcomes.

CONCLUSION

Orthodontic traction of impacted teeth involving GCB is a highly predictable procedure. The age of patients significantly affects the success rate. The younger the patients, the higher the success rate. Gender and ethnicity do not have any significant effects on the success rate.

Ethical approval

The study approved by the Scientific Review Panel at National Dental Centre Singapore, number (361/2021), dated 21 July 2022.

Declaration of patient consent

Patient's consent is not required as patients identity is not disclosed or compromised.

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Nil.

Conflicts of interest

There are no conflicts of interest.

Use of artificial intelligence (AI)-assisted technology for manuscript preparation

The authors confirm that there was no use of artificial intelligence (AI)-assisted technology for assisting in the writing or editing of the manuscript and no images were manipulated using AI.

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