ORIGINAL ARTICLE

CONTENTS

Comparative analysis of treatment options for impacted mandibular canines in different age groups of patients. A retrospective study

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ABSTRACT

Aim: To analyze the effectiveness of traditional treatment options for impacted mandibular canines in adolescents and young people while considering age, the number of impacted teeth, type of treatment, and orthodontic appliances.

Materials and Methods: The retrospective investigation of the data of the case histories of patients with impacted mandibular canines was done: 53 cases in children and adolescents (Q1-Q3 = 13 to 15 years) (Group I) and 19 in young adults (Q1-Q3 = 21.25 to 33.5 years) (Group II). The anamnesis data and clinical examination, x-ray findings, jaw model findings, treatment methods, and results were studied.

Results: In Gr. I, unilateral impaction prevailed (71.7%), whereas 20.8% of patients had bilateral impaction of mandibular canines. In Gr. II, 57.9% of patients had unilateral impaction, whereas 26.3% had bilateral impaction of mandibular canines. There is a strong correlation between the treatment outcomes and the patient's age, the number of impacted teeth, and the type of orthodontic appliance.

Conclusions: The findings indicate the risk of poor treatment effect increases with the patient's age and the kind of appliances. the number of retained teeth, and their location in the jaw.

KEY WORDS: tooth impaction, orthodontic traction, lower canines, custom-made fixed appliance

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INTRODUCTION

Numerous studies indicate that between 1–3.5% of individuals in the white population have impacted upper canines, while 0.92–1.35% have impacted lower canines, making these conditions the second most prevalent after the impaction of third molars . Although there are numerous theories explaining tooth impaction, the specific causes of this condition remain unknown [1,2].

Clinical tests play a crucial role in diagnosing impaction, and panoramic radiographs are frequently used to confirm the clinical diagnosis of canine impaction. Cone beam computed tomography (CBCT) is the most effective procedure for identifying root resorption in adjacent teeth, examining the position of the root of the impacted tooth in the jawbone. In orthodontics, the degree of canine angulation with the presence of space in the dentition at the diagnostic stage are considered a risk factors of successful eruption [3,4].

The management of tooth impaction involves a combination of surgical, orthodontic, and periodontal approaches, each with a specific sequence and level of intervention. Treatment options for ectopically positioned canines include observation, interceptive treatment, orthodontic extrusion, transalveolar transplantation, and canine extraction [5-7]. A significant number of scientific sources indicate the predominant use of fixed appliances with additional anchorage during the orthodontic stage of treatment.

Current scientific advances, including the rationale for various treatment options for tooth impaction and the ability to manage the treatment process, require the identification of factors that influence the treatment of this anomaly.

AIM

The study aimed to analyze the effectiveness of traditional treatment options for impacted lower canines

Table 1. Prevalence of lower canine impaction in groups, types, and effectiveness of treatment

№	Background and parameters	Characteristics	Group I			Group II		
			N 53, abs. (%)	girls	boys	N 19, abs. (%)	females	males
				N 30, abs. (%)	N 23, abs. (%)		N 13, abs. (%)	N 6, abs. (%)
1	Type of impaction	Unilateral	38(71.7)	21(70.0)	17(73.9)	11(57,9)	9(69.2)	2(33.3)
		Bilateral	11(20.8)	6(20.0)	5(21.7)	5(26,3)	2(15.4)	3(50.0)
		3 or more teeth	1(1.9)	1(3.3)	0	1(5,3)	0	1(16.7)
		Transmigration	3(5.7)	2(6.7)	1(4.3)	2 (10,5)	1(7.7)	1(16.7)
2	Consent	Yes	42(79.2)	27(90.0)	15(65.2)	11(57.9)	7(53.8)	4(66.7)
		No	11(20.8)	3(10.0)	8(34.8)	8(42.1)	6(46.2)	2(33.3)
3	Type of treatment	Interception	18(34.0)	11(36.7)	7(30.4)	1(5.3)	1(7.7)	0
		Orthodontic appliances and surgical exposure	23(43.4)	15(50.0)	8(34.8)	10(52.6)	6(46.2)	4(66.7)
		Refusal	12(22.6)	4(13.3)	8(34.8)	8(42.1)	6(46.2)	2(33.3)
4	Type of orthodontic appliances	Removable	7(13.2)	6(20.0)	1(4.3)	0	0	0
		Fixed	21(39.6)	11(36.7)	10(43.5)	6(31.6)	5(38.5)	1(16.7)
		Custom fixed	4(7.5)	2(6.7)	2(8.7)	0	0	0
		Removable and fixed	1(1.9)	0	1(4.3)	0	0	0
		Fixed and custom fixed	9(17.0)	8(26.7)	1(4.3)	4(21.1)	2(15.4)	2(33.3)
		Refusal	11(20.8)	3(10.0)	8(34.8)	9(47.4)	9(69.2)	0
5	Treatment	Effective	25(47.2)	15(50.0)	10(43.5)	2(10.5)	2(15.4)	0
		Satisfactory	14(26.4)	10(33.3)	4(17.4)	6(31.6)	3(23.1)	3(50.0)
		Unsatisfactory	2(3.8)	1(3.3)	1(4.3)	0	0	0
		Extraction	3(5.7)	1(3.3)	2(8.7)	6(31.6)	4(30.8)	2(33.3)
		Observation	7(13.2)	3(10.0)	4(17.4)	5(26.3)	4(30.8)	1(16.7)
		Didn't receive treatment	2(3.8)	0	2(8.7)	0	0	0

in adolescents and young people while taking into account age, the number of impacted teeth, type of treatment, and orthodontic appliances

MATERIALS AND METHODS

After analyzing medical records of individuals, who sought consultation and treatment for "positional anomalies of teeth" at the orthodontic department of the Dental Medical Center of Bogomolets National Medical University (NMU) between 2018 and 2023 years, a total of 812 clinical cases were identified in the "impacted teeth" category. During our subsequent examination of the medical records, we specifically selected the patients with mandibular canine impaction. Among these records, there were 53 (6,5%) cases involving children and adolescents and 19 (2,3%) cases involving young adults. The participants were divided into two groups. Group I (hereinafter referred to as Gr. I) included 53 children and adolescents (30 females and 23 males). The average age of these patients (median value and interquartile range) was Mel=14 years (Q1-Q3 = 13 to 15 years). Group II (hereinafter referred to as Gr. II) included 19 young adults (13 women and 6 men). The average age was MeII=25 years (Q1-Q3 = 21.25 to 33.5 years). The study received approval from the Bioethics Committee of Bogomolets NMU. Every participant, or their parents or guardians, provided informed consent for diagnostic and treatment procedures, as well as observation. This consent was obtained following the Declaration of Helsinki of the World Medical Association, which outlines ethical principles for medical research involving human subjects.

The collected data were analyzed using EZR v. 1.66 (a graphical user interface for R statistical software version 4.3.1 developed by the R Foundation for Statistical Computing in Vienna, Austria) [8]. To predict the risks of reduced effectiveness in treating retained

Table 2. Analysis of univariate logistic regression models for predicting the risk of not achieving the full treatment effect

Factor variables		Coefficient of the model, b±m	The level of significance of the difference OR from 1, p	Model odds ratio indicator, OR (95% CI)	Area under the operating characteristics curve, AUC (95% CI)
Gender	F		Reference		–
M	-0.22±0.59	0.703	–		
Age, years		0.40±0.16	**0.014**	**1.49 (1.08 – 2.06)**	**0.79 (0.65 – 0.89)**
Impaction	1		Reference		**0.66 (0.52 – 0.79)**
	2 or 3	1.83±0.73	**0.012**	**6.29 (1.49 – 26.4)**	
Type of treatment	1		Reference		**0.70 (0.56 – 0.82)**
	2	1.88±0.67	**0.005**	**6.56 (1.77 – 24.4)**	
Appliances	2		Reference		**0.71 (0.57 – 0.83)**
	1 or 3	0.13±0.75	0.858	–	
	4 or 5	2.48±0.87	**0.004**	**12.0 (2.20 – 65.5)**	

Note. Factor variables (Table 1): Impaction: 1 - Unilateral, 2 - Bilateral, 3 - 3 or more teeth.
Type of treatment: 1 - interception, 2 - orthodontic appliance with surgical exposure.
Appliances: 1 - removable, 2 - fixed, 3 - custom fixed, 4 - removable+fixed, 5 - fixed+custom-made fixed.
Reference vs. others (2 or 3 combined).

Table 3. Analysis of the three-factor logistic regression model for predicting the risk of not achieving the full therapeutic effect

Independent factor variable		Coefficient of the model, b±m	The level of significance of the difference OR from 1, p	Model odds ratio indicator, OR (95% CI)
Age, years		0.49±0.20	**0.016**	**1.63 (1.10 – 2.43)**
Impaction	1		Reference	
	2 or 3	1.76±0.94	0.062	5.80 (0.92 – 36.7)
Appliances	2		Reference	
	1 or 3	0.94±0.88	0.289	–
	4 or 5	2.33±0.98	**0.007**	**10.3 (1.50 – 71.3)**

Note. Factor variables (Table 1): Impaction: 1 - Unilateral, 2 - Bilateral, 3 - 3 or more teeth.
Appliances: 1 - removable, 2 - fixed, 3 - custom fixed, 4 -removable+fixed, 5 - fixed+custom-made fixed.
Reference vs. others (2 or 3 combined).

mandibular canines, the method of building logistic regression models was used. The degree of correlation of factor signs with the probability of decreased treatment effectiveness was assessed using odds ratio (OR) indicators along with a corresponding confidence interval (CI). The model was evaluated using receiver operating characteristic (ROC) analysis to determine the optimal cut-off point (OCP). The results of the ROC analysis are presented as the average area under the ROC curve (AUC) with its 95% confidence interval (95% CI), sensitivity (Se), and specificity (Sp) corresponding to the discriminating point. The critical level of significance in the analysis is α=0.05. The interpretation of the area under the ROC curve concerning diagnostic accuracy is as follows: 0.9-1.0 - excellent, 0.8-0.9 - very good, 0.7-0.8 - good, 0.6-0.7 - satisfactory, 0.5-0.6 - unsatisfactory; a value of 0.5 indicates the marker is not suitable for prognosis [9]. The ROC analysis yields the average value of the area under the ROC curve (AUC), with its 95% confidence interval (95% CI), sensitivity, and specificity at the discriminating point.

RESULTS

The distribution of impacted canines was as follows in number and location. In Gr.I (Table 1), the prevalence of unilateral impaction of the mandibular canine was higher in girls and boys, with rates of 70.0% and 73.9%, respectively. A total of 20.8% of individuals had bilateral impaction of mandibular canines, whereas just one person had retention of both maxillary and mandibular canines. Three patients demonstrated transmigration of the mandibular canines. They intersected the mandible's symphysis at various angles relative to the midline. In Gr. II, over 50% of the patients had unilateral impaction of the mandibular canine, whereas a quarter had bilateral

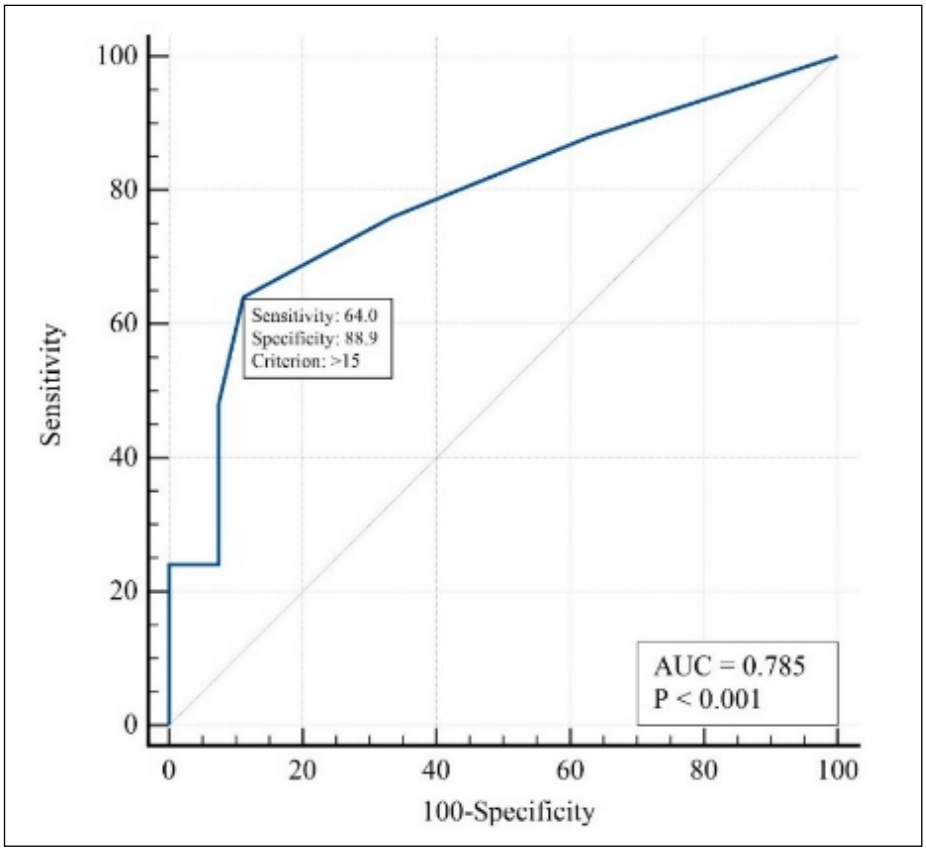

Fig. 1. Receiver operating characteristic (ROC) curve for predicting the risk of not achieving the full treatment effect by patient age.

impaction of the mandibular canine (Table 1). In one case, three canines were impacted. Mandibular canine transmigration was detected in two adults.

Following a thorough assessment, 79.2% of patients, mostly girls, agreed to treatment in Gr. I. One-third of the boys refused treatment. In Gr. II, a total of 57.9% of individuals provided their consent for treatment. Nevertheless, in this particular group, a significant proportion of women (46.2%) refused treatment (Table 1). In Gr. I, the impaction of mandibular canines was managed by a combination of interception (34%) and by consistent planned use of orthodontic appliances and surgical exposure (43.4%). Gr. II exhibited a significantly higher proportion of patients who declined therapy (42.1%) in comparison to Gr. I (20.8%). Orthodontic appliances and surgical exposure were used for canine eruption, mainly, in Gr.II (52.6%) (Table 1).

It has been established that orthodontic appliances were used more often simultaneously and sequentially: removable and standard fixed appliances, as well as standard fixed appliances and custom-made fixed appliances. In Gr. I, a minority of patients (13.2%) were treated with removable appliances, while the majority (39.6%) were treated with standard fixed appliances. In complicated cases, standard fixed appliances were combined with auxiliary anchorage and custom-made fixed appliances (17.0%) (Table 1). In Gr. II, 31.6% of patients underwent treatment using standard fixed appliances with auxiliary anchorage, while 21.1% of patients were treated using standard fixed and custom-made fixed appliances, either simultaneously or sequentially. In Gr. I, one adolescent willingly consented to undergo treatment but refused to use any orthodontic appliances after a temporary canine tooth extraction. In Gr. I, dental extractions were performed on 5.7% of patients (two teeth were in transmigration). One patient refused to have the extraction procedure, opting instead for observation. One tooth of the teenager was removed due to the formation of a cyst. In Gr. II, extraction was used as a treatment strategy for impaction in 31.6% of cases. Patients who refused treatment and did not have their teeth removed were periodically observed. The proportion of such patients was 13.2% in Gr. I and 26.3% in Gr. II (Table 1).

Throughout treatment, one adolescent refused to continue treatment, so further analysis was for 52 participants. Effective treatment were observed in 27 individuals, corresponding to the outcome variable Y=0 (effect achieved), which determined the treatment as effective. Out of the total number of patients, 25 cases were classified as Y=1 (no effect), where the treatment was assessed as satisfactory, unsatisfactory, or tooth extraction. The analysis was conducted for 5 variables:

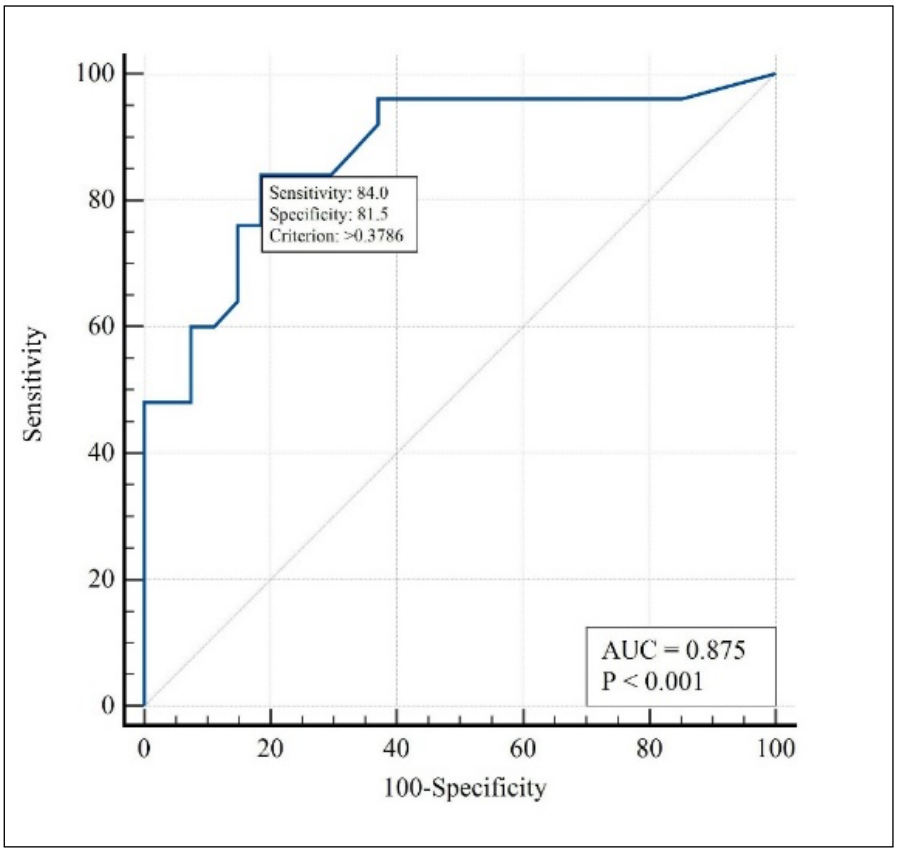

Fig. 2. Receiver operating characteristic (ROC) curve of the three-factor logistic regression model for predicting the risk of not achieving the full treatment effect.

gender, age, retention, orthodontic appliances, and type of treatment (Table 2).

A univariate analysis revealed no significant correlation between the risk of not achieving the full treatment effect and the gender of the individuals being treated (p=0.703). There was a statistically significant increase (p=0.014) in the risk of not achieving the full treatment effect with increasing patient age, OR = 1.49 (95% CI 1.08 - 2.06) for each year. The study established a significantly increased risk (p=0.012) of not achieving the full treatment effect for those with bilateral impaction and the presence of three or more impacted teeth in both jaws OR = 6.29 (95% CI 1.49 - 26.4) compared to those with unilateral impaction. When using orthodontic appliances and surgical intervention, there is a greater risk of not achieving the full treatment effect (p=0.005), OR= 6.56 (95% CI 1.77 - 24.4) compared to interceptive treatment. There was also a significantly higher risk (p=0.004) of not achieving the full treatment effect: OR = 12.0 (95% CI 2.20 - 65.5), when comparing the combination of removable and standard fixed appliances to the combination of standard fixed appliances and custom-made fixed appliances. For such approaches the correlation between patient age and the risk of not achieving the full treatment effect is pronounced - AUC = 0.79 (95% CI 0.65 - 0.89). Figure 1 shows the operating characteristics curve of this model.

When selecting the optimal threshold (age>15 years) based on the Youden Index, the sensitivity of this model is 64.0% (95% CI 42.5% - 82.0%), and the specificity is 88.9% (95% CI 70.8% - 97.6%). The sensitivity and specificity of a univariate logistic regression model for predicting the risk of not achieving the full treatment effect depending on patient age (64% and 88.9%, respectively) indicate its favorable prognostic value in predicting the treatment outcomes for mandibular canine impaction provided that the patient's age is > 15.

The method of constructing multivariate logistic regression models was used to identify a group of independent factor variables that are linked to the risk of not achieving the full treatment effect... We identified three main risk factors: age, impaction, and orthodontic appliances. The model constructed using these variables is adequate (chi-square= 27.7 with 4 degrees of freedom, p<0.001). The findings of the multivariate analysis are displayed in Table 3.

In the multivariate logistic regression model, after considering other factors, it was found that the patient's age was associated with an increased risk (p=0.016) of not achieving the full treatment effect, OR= 1.63 (95% CI 1.10 - 2.43) for each year (taking into account the effect of impaction and orthodontic appliances). Additionally, there was a significantly higher risk (p=0.007) of not achieving the full treatment effect when using a combination of appliances, specifically removable appliances with standard fixed appliances,

OR= 10.3 (95% CI 1.50 - 71.3) compared to treatment with a combination of standard fixed appliances and custom-made fixed appliances. This analysis took into consideration the impact of patient age as well as the number and location of impacted teeth in the jaw. Figure 2 shows the operating characteristics curve of this model.

When selecting the optimal threshold based on the Youden Index, this model has a sensitivity of 84.0% (95% CI 63.9% - 95.5%), and a specificity of 81.5% (95% CI 61.9% - 93.7%), which, according to the generally accepted classification, indicates their significant prognostic value in predicting the treatment outcomes for mandibular canine impaction, taking into account the patient's age, the number and location of impacted canines, as well as the choice of orthodontic appliances.

Removable orthodontic appliances and standard fixed appliances were used for creating interdental space in the dentition for traction of impacted canines in Gr.1 (13.2% and 39.6%). In difficult cases (significant canine displacement, horizontal location), 17.0% of patients in Gr.1 and 21.1% in Gr.II used a combination of standard fixed orthodontic appliances with custom-made fixed appliances.

DISCUSSION

Mandibular canine impaction, translocation, and transmigration are infrequent phenomena. Multiple scientific reviews revealed the occurrence of mandibular canine impaction ranges between 0.008% and 1.7%. This is a big range of results that can be explained by different focusing on populations ranging from orthodontic patients to the general population, different ethnic groups, and different sample sizes [1,10,11]. In compartment to those data our results of mandibular canine impaction manifestation in persons of the "impacted teeth" sample proved 6,5% in children and adolescents and 2,3% in adults with the prevalence of unilateral impaction (71,7% to 57,9%). In our study, most mandibular-impacted canines occurred unilaterally without significant differences between the right and left sides which was also confirmed by the Chowdhary S. et al., review [12].

Experienced orthodontists believe that the extraction of a deciduous canine should occur between the ages of 10 and 13, ensuring the natural eruption of the permanent canine. The timing of diagnosis is critical in terms of treatment options and therapeutic prognosis [1]. In our study, we found mandibular canine impaction in 22.6% of children aged 13 years, and, after data analysis, we can conclude that the risk of not achieving the full treatment effect after the patient's age increased (OR= 1.63 (95% CI 1.10 - 2.43) for each year. This emphasizes the importance of early identification of impaction to ensure a safer course of treatment- interception.

Stabryła J, et al. [2] proved that changes in canine angulation from a vertical to a horizontal location in the dental arch can complicate treatment. According to our investigation, a strong correlation has been established between the number of impacted teeth, their location, and the effectiveness of treatment results.

The most commonly employed treatment strategy for impacted mandibular canine surgical removal, because it was considered easier and faster than bringing the canine to its actual position[1]. Another approach is supported by the study of Stabryła J, et al [2], according to which orthodontic extrusion was most often performed to impacted mandibular canine eruption (33%), and, such treatment was successful in 95% of cases. Our research results support this data and show that for children, adolescents, and adults the most common treatment options were orthodontic traction with surgical exposure (Table 1). An univariate logistic regression model for predicting the risk of not achieving the full treatment effect depending on patient age indicates its favorable prognostic value in predicting the treatment outcomes for mandibular canine impaction provided that the patient's age is > 15.

The traction of impacted mandibular canines is always a challenge for the orthodontist. Each case of an impacted canine should be studied individually, concerning the location of the impacted tooth in the alveolar bone, occlusion, and the patient's profile [2, 12]. Agastra E. et al. review showed that the percentage of favorable to unfavorable impaction was 28.6% and 71.4% respectively [4] In compartment to this data our results show 47, 2% effective treatment for children and adolescents and 10,5% for adults.

The development of custom-made fixed appliances was necessary to achieve more effective results for challenging cases and adult patients. According to the findings of Germano F. et al. [13] and Topka A. et al. [14], these appliances allow forces to be controlled in specific directions and durations, minimizing the negative effects on abutment teeth. The findings of Inchingolo A. et al. [6] confirm that ensuring the correct aligning of the teeth in the dental arch and preserving the health of the surrounding gingival tissue is possible with the help of traction of the impacted tooth, which should imitate the natural process of tooth eruption.

Although treatment can be lengthy, successful eruption can be achieved with appropriate biomechanics, aided by CAD/CAM technologies, as well as Artificial Intelligence to minimize adverse effects and achieve the best results in rehabilitating patients with various anomalies, including teeth impaction [3,13,15].

CONCLUSIONS

The findings after our research indicate the increase in the risk of poor treatment results with the increasing patient age, with the type of appliances. the number of impacted teeth, and their location in the jaw.

Artificial Intelligence and digital diagnostics of pathology, digital design, and manufacturing of orthodontic appliances should become a promising direction for increasing the effectiveness of teeth impaction treatment, so it needs active development.

Further research is necessary to establish clinical guidelines for more active detection and early treatment of dental impactions in children and to develop algorithms for using orthodontic appliances in adults as an alternative to tooth extraction.

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CONFLICT OF INTEREST

The Authors declare no conflict of interest

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