

I.L. Skrypnyk, S.A. Shnaider<sup>1</sup>, T.O. Pyndus<sup>2</sup>, L.M. Khoroz<sup>3</sup>, A. Jenca<sup>2</sup>,  
J. Jenchova<sup>2</sup>, A. Petrasova<sup>2</sup>

Bogomolets National Medical University, Kyiv

<sup>1</sup>State Establishment “The Institute of stomatology and maxilla-facial surgery National academy of medical sciences of Ukraine”, Odesa; <sup>2</sup>PHEI “Lviv Medical University”, Lviv

<sup>3</sup>Danylo Halytsky Lviv National Medical University, Lviv

## EFFECTIVENESS OF USING A PENDULUM APPARATUS FOR DISTAL MOVEMENT OF THE FIRST PERMANENT MOLARS OF THE UPPER JAW IN CHILDREN WITHOUT ERUPTED SECOND PERMANENT MOLARS

e-mail: oksanadenga@gmail.com

The study was devoted to evaluating the effectiveness of the Pendulum appliance for distal movement of the first permanent molars of the upper jaw in children whose second permanent molars had not yet erupted. Ten patients aged between 8 and 16 years with dentoalveolar anomalies participated in the research. Lateral cephalometric radiographs were used to assess angular and linear parameters before and after treatment with the Pendulum appliance. The appliance facilitated significant distalization of the first permanent molars, achieving an average movement of  $7.48 \pm 0.64$  mm over an average treatment duration of  $3.26 \pm 0.37$  months. Minor undesirable effects, such as mesial movement of anchorage teeth and slight incisor protrusion, were observed but resolved spontaneously within 2–3 weeks after appliance removal. These findings suggest that the Pendulum appliance is effective in distalizing first permanent molars in children without erupted second permanent molars, promoting optimal occlusal relationships and potentially simplifying future orthodontic treatment.

**Key words:** anomalies of the dentition, Pendulum apparatus, molar distalization, orthodontic treatment, children.

І.Л. Скрипник, С.А. Шнайдер, Т.О. Пиндус, Л.М. Хороз, А. Єнча,  
Я. Єнчова, А. Петрашова

## ЕФЕКТИВНІСТЬ ВИКОРИСТАННЯ PENDULUM-АПАРАТУ ДЛЯ ДИСТАЛЬНОГО ПЕРЕМІЩЕННЯ ПЕРШИХ ПОСТІЙНИХ МОЛЯРІВ ВЕРХНЬОЇ ЩЕЛЕПИ У ДІТЕЙ БЕЗ ПРОРІЗАНИХ ДРУГИХ ПОСТІЙНИХ МОЛЯРІВ

Дослідження було присвячене оцінці ефективності застосування апарату Pendulum для дистального переміщення перших постійних молярів верхньої щелепи у дітей, у яких ще не прорізулися другі постійні моляри. У дослідженні взяли участь десять пацієнтів віком від 8 до 16 років із зубощелепними аномаліями. Бокові цефалометричні рентгенограми використовували для оцінки куткових і лінійних параметрів до і після лікування апаратом Pendulum. Апарат сприяв значній дисталізації перших постійних молярів, досягнувши середнього переміщення  $7,48 \pm 0,64$  мм за середню тривалість лікування  $3,26 \pm 0,37$  місяців. Спостерігалися незначні небажані ефекти, такі як мезіальний рух опорних зубів та незначна протрузія різців, але вони спонтанно зникли протягом 2–3 тижнів після зняття апарату. Ці дані свідчать про те, що апарат Pendulum ефективний для дисталізації перших постійних молярів у дітей, у яких не прорізулися другі постійні моляри, сприяє формуванню оптимальних оклюзійних співвідношень і потенційно спрощує майбутнє ортодонтичне лікування.

**Ключові слова:** аномалії зубощелепної системи, Pendulum-апарат, дисталізація молярів, ортодонтичне лікування, діти.

*The work is a fragment of the research project “Development and introduction into clinical practice of methods of diagnosis, prevention and treatment of osteogenesis disorders during dental intervention in patients in wartime” state registration No. 0123U103247.*

Malocclusions are highly prevalent in pediatric populations worldwide, significantly impacting oral health-related quality of life and functional abilities such as chewing and speech [3, 6, 7, 8]. The correction of Class II malocclusions often necessitates the distal movement of maxillary molars to achieve proper occlusal relationships [11]. Various orthodontic appliances and techniques have been developed to address this need, including headgear, clear aligners, mini-implants, and intraoral distalization appliances [5, 9].

The Pendulum appliance, introduced as a non-compliance therapy option for Class II correction, has gained attention for its effectiveness in distalizing maxillary molars without the need for patient cooperation [9]. It functions by applying continuous forces to the molars through a spring mechanism, promoting distal movement while being anchored to the premolars and an acrylic button on the palate [11]. Previous studies have demonstrated its efficacy in mixed dentition periods and its ability to create space for erupting teeth, thereby facilitating improved occlusal outcomes [11].

However, the majority of research on the Pendulum appliance has focused on patients with erupted second permanent molars, leaving a gap in the literature regarding its effectiveness in younger children

whose second molars have not yet erupted. The absence of erupted second molars may influence the biomechanics of molar distalization, anchorage requirements, and overall treatment outcomes. Understanding the appliance's performance in this specific patient population is crucial, as early intervention can prevent the progression of malocclusions and reduce the need for more invasive treatments later in life [4].

The novelty of this study lies in its focus on evaluating the effectiveness of the Pendulum appliance in distalizing the first permanent molars in children without erupted second permanent molars. This demographic represents a critical window for interceptive orthodontics, where timely intervention can leverage growth potential and simplify future orthodontic treatment [2]. By addressing the unknown outcomes of using the Pendulum appliance in this context, the research aims to fill a significant gap in orthodontic knowledge and provide clinicians with evidence-based guidance for managing similar cases.

Moreover, the study explores the appliance's impact on dental and skeletal parameters, considering potential side effects such as anchorage loss, incisor proclination, and changes in vertical dimensions [5, 11]. These factors are essential for ensuring treatment stability and patient satisfaction, as malocclusions can adversely affect not only oral function but also psychosocial well-being [6, 10].

In conclusion, this research seeks to contribute to the orthodontic field by providing insights into the efficacy and clinical implications of using the Pendulum appliance in a younger pediatric population without erupted second permanent molars. The findings have the potential to influence treatment planning strategies, optimize patient outcomes, and expand the utility of the Pendulum appliance in early orthodontic interventions [3, 12].

**The purpose** of the study was to evaluate the effectiveness of the Pendulum appliance for distal movement of the first permanent molars of the upper jaw in children whose second permanent molars have not yet erupted.

**Materials and methods.** The study involved 10 patients who applied to the Department of Orthodontics of the Bogomolets National Medical University aged 8 to 16 years with existing dentoalveolar anomalies and with second permanent molars that had not erupted. The Pendulum appliance was used for distal movement of the permanent molars of the upper jaw. The study was conducted over a period of one year, from 2020 to 2021.

The distalisation was carried out using the Pendulum appliance offered by Hilgers [9]. The appliance is a non-removable, intraoral, mechanically operated appliance that is fixed on premolars and first permanent molars and consists of standard orthodontic rings, an acrylic Nancy button, two Pendulum springs that are inserted into the palatal tubes on the first permanent molars.

The appliance was slightly modified if distal movement of permanent molars on one side was necessary. The modification consisted of leaving one Pendulum spring in the appliance on the side from which distal movement was required, and on the other side, an orthodontic wire with a diameter of 1.0–1.2 mm was soldered to the ring on the first permanent molar of the upper jaw, which ended in an acrylic button.

The appliance was activated once a week by activating the Pendulum springs at 60°, which allowed to create a force of 230 g on each side of the tooth.

After the distal displacement of the permanent molars of the upper jaw, the patients did not require further orthodontic treatment. As a rule, this is typical for patients with a distal relationship of the first permanent molars, as a result of mesial displacement of the permanent posterior teeth. Therefore, after normalisation of the position of the permanent molars of the upper jaw, the necessary space was created for the eruption of the premolars.

To determine the features of the morphological structure of the facial skull, telerradiographs of the patients' heads were used, performed in lateral projection. Lateral telerradiographs of the head were made using the "ORTHOPHOS" apparatus of "SIRONA SIDEXIS", at a focal length of 150 cm, voltage of 65–75 kV, exposure time – 1.6–2.0 s, current strength – 14 mA. The head was fixed using a cephalostat. The beam was directed to the middle of the external auditory canal. To determine the structural features of the facial skull in patients with distal occlusion, 8 angular and 8 linear parameters were studied [2].

The results were processed by variational statistical methods of analysis using the Microsoft Office Excel 2016 software. Statistical processing of the experimental study results was carried out by the methods of variation analysis using the Student's test. The difference was considered statistically significant at  $p < 0.01$  [1].

**Results of the study and their discussion.** To gain a comprehensive understanding of the Pendulum appliance's effectiveness in distalizing maxillary first permanent molars in children without erupted second permanent molars, we meticulously examined changes in specific angular and linear parameters derived from lateral cephalometric radiographs taken before and after treatment. This detailed assessment allowed us to observe not only the extent of molar distalization but also the associated dental and skeletal modifications, such as alterations in tooth angulation, positioning, and occlusal relationships. By analyzing these parameters, we could evaluate the appliance's overall impact on orthodontic correction and its influence on surrounding structures. The summarized data reflecting these significant changes are presented in Table 1.

Table 1

**Changes in angular and linear parameters before and after distal movement of maxillary molars using the Pendulum apparatus, M $\pm$ m**

Parameters	Before treatment	After treatment
Angular		
$\angle 1_{SpP}$	71.82 $\pm$ 0.46	70.12 $\pm$ 0.92
$\angle 1_{NS}$	81.47 $\pm$ 0.72	79.55 $\pm$ 0.96
$\angle 4_{SpP}$	90.06 $\pm$ 0.38	87.77 $\pm$ 0.72
$\angle 4_{NS}$	98.72 $\pm$ 0.59	96.40 $\pm$ 0.46
$\angle 5_{SpP}$	99.83 $\pm$ 0.82	102.36 $\pm$ 0.35
$\angle 5_{NS}$	107.65 $\pm$ 0.36	109.96 $\pm$ 0.42
$\angle 6_{SpP}$	107.35 $\pm$ 0.35	112.11 $\pm$ 0.88
$\angle 6_{NS}$	115.78 $\pm$ 0.56	120.62 $\pm$ 0.38
Linear		
$1_{SpP}$	28.33 $\pm$ 0.78	27.71 $\pm$ 0.64
$4_{SpP}$	24.26 $\pm$ 0.47	25.33 $\pm$ 0.72
$5_{SpP}$	22.08 $\pm$ 0.43	22.90 $\pm$ 0.32
$6_{SpP}$	20.03 $\pm$ 0.32	20.73 $\pm$ 0.25
$1-C$	59.31 $\pm$ 0.25	61.73 $\pm$ 0.28
$4-C$	48.22 $\pm$ 0.22	46.35 $\pm$ 0.14
$5-C$	40.0 $\pm$ 0.38	42.32 $\pm$ 0.42
$6-C$	30.86 $\pm$ 0.94	23.38 $\pm$ 0.65

Patients in the first group underwent lateral cephalometric radiography before and after distalization using the Pendulum appliance. Analysis of the obtained data revealed statistically significant changes in various angular and linear parameters. Specifically, there was a reduction in the angular parameters  $\angle 1_{SpP}$  and  $\angle 1_{NS}$ , associated with undesirable mesial movement of the anchorage teeth leading to incisor protrusion. Such movement can negatively affect smile aesthetics and occlusal function, necessitating consideration during treatment planning. Additionally, a decrease in the angular parameters  $\angle 4_{SpP}$  and  $\angle 4_{NS}$  was recorded, attributed to mesial tipping of the anchorage teeth as a result of distal movement of the permanent molars, which can lead to occlusal disturbances requiring correction in subsequent treatment.

Conversely, an increase in the linear parameters 1-C and 4-C was observed, indicating mesial movement of the anchorage teeth and corroborating previous observations regarding incisor protrusion and mesial tipping of premolars. Changes in these parameters are crucial for understanding the mechanics of tooth movement under the influence of the appliance. An increase in the angular parameters  $\angle 6_{SpP}$  and  $\angle 6_{NS}$  was associated with distal tipping of the molars due to their distal movement. Distal tipping of the molars can affect occlusal contacts and treatment stability, making it important to monitor this parameter and adjust the appliance design when necessary.

An increase in the angular parameters  $\angle 5_{SpP}$  and  $\angle 5_{NS}$ , along with a decrease in the linear parameter 5-C, suggests spontaneous distal movement of the second premolars with minimal distal tipping when the first premolars are used as anchorage teeth. This effect is positive, as it helps create space for other teeth and improves the overall treatment outcome. The reduction in the linear parameter 6-C was due to the distal movement of the first permanent molars, confirming the Pendulum appliance's effectiveness in molar distalization. An increase in the linear parameters 4SpP, 5SpP, and 6SpP indicates extrusion of the premolars and molars, which can influence the vertical dimension of occlusion and requires monitoring during treatment.

In patients of the first group, the amount of distal movement of the first permanent molars ranged from 3.67 mm to 11.49 mm, with an average value of  $7.48 \pm 0.64$  mm. This significant range demonstrates the effectiveness of the Pendulum appliance in molar distalization. The duration of treatment varied from 1.6 to 5.37 months, averaging  $3.26 \pm 0.37$  months, indicating relatively rapid achievement of desired results. The rate of molar distal movement was 2.29 mm per month, a high indicator in orthodontic practice. For every 1.00 mm of molar distalization, there was 0.25 mm of anchorage tooth movement, an important ratio for predicting possible changes in anchorage teeth and planning corrective measures.

The distal tipping of the first permanent molars was recorded at  $4.76^\circ$  relative to the palatal plane ( $\angle 6\text{SpP}$ ) and  $4.84^\circ$  relative to the NS plane ( $\angle 6\text{NS}$ ). Such tipping can affect occlusion and treatment stability; therefore, measures are recommended to reduce it. The mesial movement of the anchorage teeth averaged 1.87 mm, accompanied by mesial tipping of  $2.29^\circ$  ( $\angle 4\text{SpP}$ ) and  $2.32^\circ$  ( $\angle 4\text{NS}$ ). Incisor protrusion was recorded at  $1.7^\circ$  ( $\angle 1\text{SpP}$ ) and  $1.92^\circ$  ( $\angle 1\text{NS}$ ). Although these changes are undesirable, they were minor and resolved spontaneously within 2–3 weeks after appliance removal due to the action of transseptal fibers.

Extrusion of the premolars and molars was noted at 1.07 mm for first premolars (4SpP), 0.82 mm for second premolars (5SpP), and 0.7 mm for first permanent molars (6SpP). These values indicate minimal vertical tooth movement, which does not significantly impact occlusion. Spontaneous distal movement of the second premolars with minimal distal tipping is a positive effect that simplifies further orthodontic treatment and contributes to the optimal alignment of teeth in the dental arch.

The present study demonstrated the effectiveness of the Pendulum appliance in achieving significant distalization of the first permanent molars in children without erupted second permanent molars, with an average distal movement of  $7.48 \pm 0.64$  mm over a treatment duration of  $3.26 \pm 0.37$  months. These findings align with previous research that has shown the Pendulum appliance to be effective in distalizing maxillary molars, although most prior studies focused on patients with erupted second permanent molars [5, 11]. The high rate of molar movement observed in this study (2.29 mm per month) suggests that the absence of erupted second molars may facilitate more efficient distalization due to reduced resistance and anchorage demands. The minimal undesirable effects, such as slight mesial movement of anchorage teeth and incisor proclination, were consistent with other studies that have reported similar side effects when using intraoral distalization appliances [5]. However, these changes were minor and resolved spontaneously within a few weeks after appliance removal, indicating that the Pendulum appliance remains a viable option with manageable side effects. Additionally, the spontaneous distal movement of second premolars observed contributes to creating space in the dental arch, which is beneficial for accommodating erupting teeth and improving occlusal relationships [2]. This effect aligns with findings that early orthodontic intervention can leverage growth potential and simplify future treatment [4]. The minimal vertical changes, such as extrusion of premolars and molars, did not significantly impact occlusion, aligning with other research indicating negligible effects on the vertical dimension when using the Pendulum appliance [11]. Compared to other distalization methods, such as clear aligners or mini-implants, the Pendulum appliance offers a cost-effective and compliance-independent alternative, which is particularly advantageous in a pediatric population [5]. The study's results support the notion that early intervention can positively influence oral health-related quality of life by addressing malocclusions that may impair masticatory function and psychosocial well-being [3, 6]. Future research should explore modifications to the appliance design or adjunctive techniques to enhance anchorage control and minimize unwanted tooth movements. Long-term studies are warranted to assess the stability of treatment results and the impact on craniofacial development over time. In conclusion, our study adds to the body of evidence supporting the effectiveness of the Pendulum appliance in pediatric orthodontics, particularly in patients without erupted second permanent molars. The appliance's ability to achieve significant molar distalization with manageable side effects makes it a valuable tool in early orthodontic intervention. By addressing malocclusions at a younger age, we can leverage growth potential, simplify future treatments, and enhance the overall oral health and quality of life for our patients.

## Conclusions

1. The Pendulum appliance is effective for achieving significant distal movement of the first permanent molars in children whose second permanent molars have not yet erupted. The study demonstrated an average distalization of  $7.48 \pm 0.64$  mm over a relatively short treatment duration of  $3.26 \pm 0.37$  months, indicating a high rate of molar movement (2.29 mm per month).

2. While using the Pendulum appliance, minor undesirable effects were observed, including mesial movement of anchorage teeth (average of 1.87 mm) accompanied by mesial tipping ( $\angle 4\text{SpP}$ :  $2.29^\circ$ ,  $\angle 4\text{NS}$ :  $2.32^\circ$ ) and slight incisor protrusion ( $\angle 1\text{SpP}$ :  $1.7^\circ$ ,  $\angle 1\text{NS}$ :  $1.92^\circ$ ). These changes were minimal and resolved spontaneously within 2–3 weeks after appliance removal due to the action of transseptal fibers.

3. The appliance also resulted in minimal vertical tooth movements, such as extrusion of premolars and molars, which did not significantly impact occlusion. The spontaneous distal movement of second premolars with minimal distal tipping is a positive outcome that simplifies subsequent orthodontic treatment and contributes to optimal alignment within the dental arch. Therefore, the Pendulum appliance can be considered a viable and efficient treatment option for molar distalization in this patient population.

## References

1. Rohach IM, Keretsman AO, Sitkar AD. Pravylny vybranny metod statystychnoho analizu – shlyakh do yakisnoyi interpretatsiyi danykh medychnykh doslidzhen. Naukovyy visnyk Uzhhorodskoho universytetu, seriya “Medytsyna”. 2017;2(56):124–128. [in Ukrainian].
2. Flis PS. Ortodontiya. Vinnytsia: Nova knyha, 2007. 312 p. [in Ukrainian].
3. Alshammari A, Almotairy N, Kumar A, Grigoriadis A. Effect of malocclusion on jaw motor function and chewing in children: a systematic review. *Clin Oral Investig*. 2022;26(3):2335–51. doi: 10.1007/s00784-021-04356-y.
4. Antoun JS, Fowler PV, Jack HC, Farella M. Oral health-related quality of life changes in standard, cleft, and surgery patients after orthodontic treatment. *Am J Orthod Dentofacial Orthop*. 2015;148(4):568–75. doi: 10.1016/j.ajodo.2015.03.028.
5. Caruso S, Nota A, Ehsani S, Maddalone E, Ojima K, Tecco S. Impact of molar teeth distalization with clear aligners on occlusal vertical dimension: a retrospective study. *BMC Oral Health*. 2019;19(1):182. doi: 10.1186/s12903-019-0880-8.
6. Choi SH, Kim JS, Cha JY, Hwang CJ. Effect of malocclusion severity on oral health-related quality of life and food intake ability in a Korean population. *Am J Orthod Dentofacial Orthop*. 2016;149(3):384–90. doi: 10.1016/j.ajodo.2015.08.019.
7. De Ridder L, Aleksieva A, Willems G, Declerck D, Cadenas de Llano-Pérula M. Prevalence of Orthodontic Malocclusions in Healthy Children and Adolescents: A Systematic Review. *Int J Environ Res Public Health*. 2022;19(12):7446. doi: 10.3390/ijerph19127446.
8. Londono J, Ghasemi S, Moghaddasi N, Baninajarian H, Fahimipour A, Hashemi S, et al. Prevalence of malocclusion in Turkish children and adolescents: A systematic review and meta-analysis. *Clin Exp Dent Res*. 2023;9(4):689–700. doi: 10.1002/cre2.771.
9. Nissen SH. The Pendulum Appliance for Class II Non-Compliance Therapy. *J Clin Orthod*. 2017;51(9):564–567.
10. Palomares NB, Celeste RK, Miguel JA. Impact of orthosurgical treatment phases on oral health-related quality of life. *Am J Orthod Dentofacial Orthop*. 2016;149(2):171–81. doi: 10.1016/j.ajodo.2015.07.032.
11. Paranna S, Shetty P, Anandakrishna L, Rawat A. Distalization of Maxillary First Permanent Molar by Pendulum Appliance in Mixed Dentition Period. *Int J Clin Pediatr Dent*. 2017;10(3):299–301. doi: 10.5005/jp-journals-10005-1454.
12. Yosra T, Abdoul Hafizou RA, Fatima Z, Hicham B. Orthosurgical approach of a skeletal class III malocclusion with mandibular laterognathia: a case report. *Ann Med Surg (Lond)*. 2023;85(6):2965–73. doi: 10.1097/MS9.0000000000000591.

Стаття надійшла 7.12.2023 р.