ABSTRACT:
The borderline indications between extraction and non-extraction treatment are not well defined in the orthodontics. The sagittal tooth movement for lengthening the tooth arch and space gaining should be considered with several aspects. Many authors have suggested appliances with combined action in several planes. In our opinion, it is very hard to achieve transverse dimension and apply well balanced sagittal force with one appliance. Our aim is to define the gained space in the dental arch using two successive appliances: RME and M-pendulum modified by us for remaining the transverse arch dimensions. We suggest a modification of the appliance remaining the achieved transversal dimension during the molar distal movement. We added an additional wire grill to the classic design of the M-Pendulum appliance in 14 patients. The length of the dental arch can be increased with expansion (RME), molar rotation correction with 2mm, distal movement of the upper molars 3-4mm, protrusion of the frontal teeth 1.5mm, slenderizing 4mm. The sum of all these methods reaches the amount of the dimension of the space gained with the extraction of two premolars. A single appliance cannot achieve the full amount of tooth movement. The modified by us M-pendulum perfectly keeps the achieved transverse dimension right after the RME and achieves sagittal movement of the upper molars.

Keywords: rapid palatal expansion, pendulum appliance, tooth movement, non-extraction treatment

INTRODUCTION
The borderline indications between extraction and non-extraction treatment are not well defined in the orthodontics [1, 2, 3]. The effect of the distalisation appliance is contentious about the gained space. The sagittal tooth movement for lengthening the tooth arch and space gaining should be considered with the following aspects: occlusal norm, functions in the oral cavity, facial aesthetics, periodontal health, condition of the TMJ and the stability of the result [4, 5, 6, 7]. The possibilities of lengthening the dental arch and space gaining are also possible with its transversal expansion and even with vertical changes. In the early stages of the development of the dentition for example in mixed dentition, the functional appliance may reduce the chance of an extraction cases later. The functional appliance cannot create additional apical bone structures. That is why the only alternative in permanent dentition is treatment with a mechanical appliance or extraction treatment [8, 9]. In the non-extraction treatment, we achieve the most functional occlusion, optimal aesthetics, undamaged periodontal ligaments, full numbers of teeth assures support of the facial soft tissues and the patient has a broad smile. Because of this, the orthodontists use the effect of various methods for lengthening the dental arch in the three dimensions [10].

The perimeter of the dental arch can be increased with expansion (rapid maxillary expansion), molar rotation correction with 2mm, distal movement of the upper molars 3-4mm, protrusion of the frontal teeth 1-3mm, slenderizing 4-6mm. The sum of all these methods reaches the amount of the dimension of the space gained with the extraction of two premolars [11, 12, 13, 14]. Therefore the extraction of the premolars can be avoided in most of the cases. Authors offer their methods in gaining space in the dental arch (distalizing upper molar, transversal expansion, protrusion of interior teeth, molar derotation etc.) It often happens that two or more methods are applied in the course of the same treatment. One important task is to preserve the already gained space during the tooth alignment treatment stage [14, 15, 16]. Contemporary orthodontics applies mini screw for anchorage of the relocated teeth or appliances with combined double-way action. Hilgers, when constructed the appliance, suggested integrating a jackscrew in the palatal plastic button [17]. In this modification, the appliance’s action is like removable expansion appliance. Its action is only dento-alveolar. With the more frequent usage of the appliance in the clinical practice, other authors [17, 18] suggest modification with wire construction and bands on the first premolars and molars and jackscrew for rapid expansion. After the expansion has finished the construction is separated, and the distalization springs are activated. The appliances are effective but hard to construct, and after the expansion, the distalization springs do not fit in the new transverse dimension. There is dimension loses for compensation.
AIM
Our objective is to find out if borderline cases in orthodontics can be solved with a combination of appliances achieving results in different planes. Our aim is to create a clinical protocol for the successive using of the appliances RME (rapid maxillary expansion) and M-pendulum.

MATERIALS AND METHODS
Our method is applicable to patients treated without extraction, and it requires transversal expansion and distalisation of upper molars. These patients most often have class II malocclusions.

The maxillary expansion is successful in patients with compression. The result is unstable in cases in which the teeth are buccally tipped, without any skeletal change. The stability in these cases is poor. Better results will be achieved with rapid maxillary expansion, which creates space by real bone remodelling. The impact of the buccal soft tissues and the new position of the teeth are well balanced. Whatever the achieved results are, the only way of keeping them is fixed retention.

Therefore, for the treatment to be continued with the pendulum appliance for the distalization of the upper molars, it is necessary to retain the new transversal dimension of the dental arch. That is why we need an appliance whose design assures the new transversal dimension of the dental arch and moves the molars at the same time.

On the basis of our clinical experience with the Pendulum appliance, we suggest a modification which can remain the achieved transversal dimension during distal movement of the molars.

Fig. 1. Modified pendulum appliance with wire grill

Our suggestion for this problem is to use successively the classic appliance – fix rapid expander. To remain the transverse dimension in the dental arch after the rapid maxillary expansion, we suggest adding an additional element to the classic construction of the M-Pendulum appliance. The additional element is a wire grill (fig.1). It reaches the palatal surface of the cervix of the first and second premolars. The premolars are the anchorage area of the appliance. The grill is positioned close to the cervix near the centre of resistance. The grill blocks the teeth so they cannot return to their previous position or tip. Part of the grill is separated when the second premolars need to drift distally.

We have treated 14 patients with class II or III malocclusions and crowding in the upper arch between 8-10mm. The occlusal relationships were impaired with cross bite with different gravity. The cross bite has been caused by the narrowness of the upper jaw. The lack of space in the upper dental arch is due to the medialization of upper posterior teeth.

Our clinical protocol included: Transversal expansion; Distalization of upper molars; Alignment of the upper arch; Alignment of the lower arch; Normalizing the occlusal relationship; Retention of the clinical result.

The results we were reporting before and after the appliance using the following methods: the Transversal dimension of the upper dental arch in the first premolars and molars; Measuring a perimeter of dental arch from a distal end of the last molar to the distal end of the opposite molar; Ceph sagittal parameters (fig.2).

Fig. 2. Methods for the dental cast and cephalometric measurement. Measurements are made before and after using the appliance.

RESULTS
We achieved alignment and levelling of all teeth, and optimal occlusion in patients treated successively with the appliances. The new transversal dimensions were preserved during and after the treatment with M-Pendulum and brackets.

By the use of the maxillary expansion, a normal width of the upper dental arch in the premolars and molars’ zone is achieved. This improved transversal occlusal relations (cross bite) between the jaws. It is resulted in achieving the space of 2-2.5 mm in the dental arch. Introducing by us an additional wire grill, in the Pendulum design, reserved well this new transversal width of the upper arch. The grill was especially useful acting as a contra force on the support zone at the time of the work of the Pendulum appliance. The premolars are basically incorporated into the support zone. The grill reinforces and stays also the position of the premolars.
During the distal movement personally of the second premolar (known also as a drift), we have released its occlusal stop, and it moves in the distal direction on the alveolar ruge led by the wire grill. This insures and directs its movement on the new width of the alveolar ruge.

Applying the distalization process of the upper molars, we achieved 3.8 mm bilateral distalization of the first molars (in the range from 2 to 4.5 mm). For the whole dental arch, it comes to 7.6 mm. In most of the patients, the distalization process passes firstly through the de-rotation stage of the upper first molars followed by the distal movement. De-rotation of the molars also reflects on the transversal molar width, because of the changed position of the rapper measurement points.

We found out that the protrusion of the frontal teeth has averagely 2° which was very useful in patients with upper jaw protrusion.

**DISCUSSION**

As a result of the treatment, we achieved better levelling of the upper dental arch when there was a big shortage of space in it. In patients with class III malocclusions, the other decision was an extraction of the two upper premolars, but this will deeper the occlusal disorders (class III malocclusions) and will result in compensatory extraction of four premolars. In patients with class II malocclusions, this clinical protocol preserves the integrity of the upper dental arch and helps for normalization of the occlusal relation between the two jaws.

This clinical protocol avoided extraction treatment in these patients. We can prove our statement with the following clinical cases:

**Clinical Case 1**

We present a female patient of 12 years old with severe crowding and compression in the upper jaw, bilateral cross bite and lack of space for the alignment of the upper canines. The patient has class II malocclusion, division 1, anterior cross bite ant and vertical edge to edge occlusion. The treatment plan included rapid maxillary expansion, distal movement of the upper molars with the modified M-pendulum appliance and alignment the teeth with brackets.

**Fig. 3.** Treatment progress.

**Fig. 4.** Change the cephalometric measurement and skeletal structure of the patient.
After the three stages of the orthodontic treatment we resulted in making space in the upper dental arch for levelling the teeth, the occlusal relationships went to normal in the tree plates, and the skeletal and the soft tissue parameters were upgraded.

**Clinical case 2**

We present a male patient 12 years old diagnosed with underdevelopment of the upper jaw in transverse and sagittal dimension. The posterior teeth are medialized, and there is no space for the canines, which are located vestibular. The patient has class III malocclusion, anterior and posterior crossbite and deep palate and deviated midline.

The orthodontic treatment plan included rapid maxillary expansion distal movement of the posterior teeth and alignment of the canines and palatal positioned lateral incisor, normalizing the occlusion – medial traction the upper jaw with a face mask.

**Fig. 5.** Clinical succession the appliances in the upper dental arch.
The medial movement of the first premolars and the expansion were remained using the grill touching the palatal surface of the premolars. We achieved the desired distal movement of the first molars without any mesial movement of the premolars and reducing the space for the canines. By the final levelling of the teeth in the dental arch, we used the quad helix, which we gradually reduced. The rapid expansion and distal movement of the upper molars caused the formation of a tooth-induced bone.

Fig. 6. Change the occlusal relationship from class III to class I

There was a space in the upper dental arch – 9.5mm, which is enough to arrange the canines and the lateral. The expanded upper arch creates an opportunity the occlusion to normalize (crossbite).

Another alternative for the treatment of this clinical case is an extraction treatment of four premolars. This opportunity was explained to the patient and his parents, but they chose non-extraction treatment. The non-extraction treatment it is longer in time because it goes through several clinical stages.

CONCLUSION
A single appliance cannot achieve the full amount of tooth movement. Therefore, it is necessary to use several appliances in one treatment. In these clinical cases, it is particularly important to preserve the effect achieved on each of them. The modified by us M-pendulum perfectly keeps the achieved transverse dimension right after the RME and achieves sagittal movement of the upper molars. By this way, we can assure a non-extraction treatment to our patients. We recommend its use by the clinicians.

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**Please cite this article as:** Yordanova G, Mladenov M, Gurgurova G. Combining the action of the Pendulum appliance with rapid palatal expansion. *J of IMAB*. 2017 Oct-Dec;23(4):1752-1757.

DOI: https://doi.org/10.5272/jimab.2017234.1752

Received: 21/08/2017; Published online: 16/11/2017

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