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Spring-bite: a new device for jaw motion rehabilitation. A case report

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SUMMARY

The present paper describes the design features, potential indications and a clinical application of a newly designed device for jaw motion rehabilitation, the Spring-Bite. This device is characterized by a first class lever mechanism, which allows performing passive jaw motion rehabilitation at constant load without an active participation by the patient. Spring-Bite was developed for the management of temporomandibular joint (TMJ) hypomobility and its application may be much useful in the post-operatory phases of TMJ or orthognathic surgeries as well as in patients with reduced muscular force.

Key words: spring-bite, physiotherapy, temporomandibular joint, rehabilitation.

INTRODUCTION

Restricted mouth opening is a sign of the presence of stomatognathic impairment, and may be present in cases of temporomandibular joint diseases as well as masticatory muscle disorders (1, 2), representing a treatment-needing condition (3).

Moreover, a restricted range of jaw motion is a frequent finding in the immediate post-operatory phases of temporomandibular joint surgery interventions, and recent observations have put the attention on the need for a thorough and extensive post-surgical rehabilitation to improve jaw function (4).

In both cases, physiotherapy may be much useful to restore an acceptable range of jaw motion (5-7). The most common physiotherapic approaches include manual techniques for TMJ manipulation, relaxation exercises, stretching of the masticatory muscles, massages, posture and coordination exercises, moist heat applications (8). Moreover, some devices for passive jaw motion rehabilitation have been introduced in the temporomandibular disorders (TMD) practice, and preliminary literature findings suggested their potential usefulness to improve jaw motion (9, 10).

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The present case report describes the design features, potential indications and an example of clinical application of a new device for jaw motion rehabilitation.

SPRING-BITE DESIGN

The rationale for the design of a device for jaw motion rehabilitation is that, ideally, in order to improve jaw function and range of motion, the following requirements should be satisfied: a) wide range of mouth opening; b) adjustable maximum force applied to the jaw; c) sustained and constant stretch at the desired range of motion; d) periodic repetition of the exercise at invariant conditions also in case of non-cooperating subjects or patients with reduced muscle force. In addition, a suitable device should be easily used by the patient him/herself for the entire exercise session without help from an external operator.

Among the different devices that may force an increase in mouth opening (e.g. wooden cones or plastic screws), a lever type device should be considered to satisfy all the cited requirements. Three classes of lever devices can be used: 1) first class (e.g. scissors, pincers, etc.), in which effort and load act at opposite side with respect of the fulcrum; 2) second class (e.g. nutcracker, etc), in which effort and load are both applied at the same side with respect of the fulcrum, and effort arm is larger than load arm; 3) third class (e.g. tweezers), in which effort and load are both applied at the same side with respect of the

Fig. 1. The Spring-Bite device

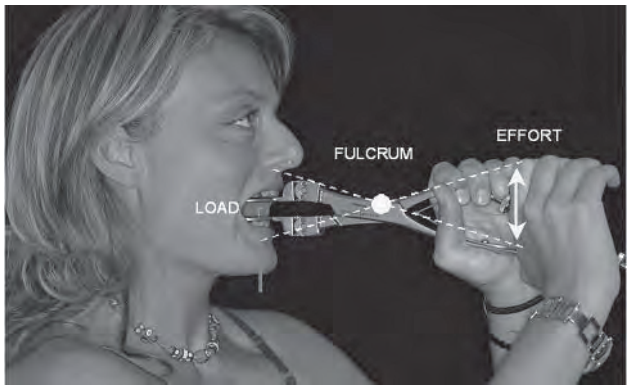

Fig. 2. The Spring-Bite device operates as a first class lever

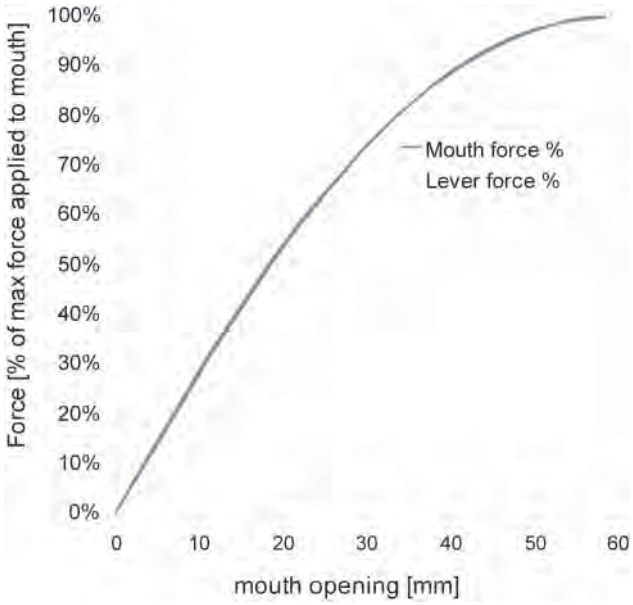

Fig. 3. Efficiency of the first type lever device. The assessment of the percentage of relative lever and mandibular forces with respect to mouth opening values was based on mechanical engineering principles

fulcrum as in second class levers, but effort arm is smaller than load arm.

Currently available devices are based on a third class lever, and encouraging findings have been reported on their use in TMD patients (9, 10). However, comparing the efficiency of the different lever devices, the third class levers are the least efficient, because the applied load is always larger than the sustained effort according to the inverse ratio of the respective arms. Second class levers are more efficient, but they can hardly be adopted as mouth opener, because the fulcrum should be put inside the mouth, which is a condition that is impossible to satisfy.

In this paper, Spring-Bite, a new jaw muscles exerciser operating as a first class lever, is presented (Figures 1, 2). Spring-Bite has been developed and clinically tested for the management of joint hypomobility and muscular trismus. The peculiarity of this device is the passive action it exerts on jaw muscles by means of an adjustable spring. The device consists of two mouthpieces inserted inbetween the upper and lower teeth, and activated by a spring that applies the required opening force on the mouthpieces. Two nuts allow mouth opening range and opening force adjustment.

Spring-Bite fits all the requirements stated above:

a) It may force mouth opening up to more than 50 mm;

b) According to spring characteristics and nuts setting, the force applied to the mouthpieces can be adjusted in a very wide operating range (e.g. between 50 and 500 N at 50 mm mouth opening). In addition, the peculiar arrangement of the spring mounted between the device levers allows the progressive increase of the opening force applied to the mouthpieces when the opening range increases, as shown in Figure 3. Also evidenced in Figure 3 is the high efficiency of the device that requires a limited force applied to the levers when compared to the force exerted at the mouthpieces.

c) The spring driven mechanism may keep the mouth opened indefinitely without external intervention. It can be removed easily by compressing the spring using the levers.

d) The spring activation assures that a suitable force profile is applied at mouthpieces, even if another person operates the device: as a matter of fact, the maximum force is set by spring – nuts arrangement, while the operator intervention can only limit the appied force acting on the levers. Moreover, periodic repetition of the exercise can be easily accomplished with the desired cycle time.

CASE REPORT

A 21 years-old man affected by nemaline myopathy presented a severe facial dysmorphism and was scheduled for orthognathic surgery. The patient had a type III skeletal profile with a severe anterior open bite and underwent a Le Fort I surgical intervention. A 3 mm posterior increase and a 4 mm anterior shift were performed along with a concurrent bilateral sagittal mandibular osteotomy with a 4 mm posterior shift. Titanium plates were positioned to warrant osteosynthesis. In the immediate post-surgical phase, an elastic guide was positioned and removed fifteen

Fig. 4. Clinical application of Spring-Bite

Fig. 5. Mouth opening after a cycle of exercises with Spring-Bite

days afer surgery. At the end of this period, a mouth opening restriction (11 mm) was evident, and the patient was trained to perform jaw motion rehabilitation by the use of the Spring-Bite device. A protocol providing a five-minute exercises forcing a passive maximum mouth opening was performed five times a day for the following fifteen days (Figure 4). A 30 mm mouth opening was achieved. After that period, the Spring-Bite device was used twice a day for the next six months, and mouth opening values were kept constant over the entire observational span, with no relapse of occlusal disharmonies (Figure 5).

DISCUSSION

Physiotherapy has been gaining much attention in recent years as an useful treatment modality for many patients affected by stomatognathic impairment.

Manual manipulation, stretching exercises and postural correction seem to be effective to improve range of motion and reduce TMJ pain (8). In particular, passive stretching of the jaw muscles, which is achieved when the patient opens the mouth to the full limit of movement and is then gently stretched beyond the restriction, seems to be one of the most useful approaches to cases of restricted mouth opening (11).

The main concern associated with such technique is related to the difficulties to achieve repeatability of the exercises in terms of time length and applied force, so that risk-to-benefit ratio is hard to assess in the clinical setting. Indeed, prolonged over-stretching of the elevator muscles can stimulate inflammatory reactions within the temporomandibular joint or provoke damage within the muscles (12).

Thus, repeatability of passive stretching with known and constant load forces should be considered an important target for stomatognathic rehabilitation in order to optimize benefits and reduce risks for damage.

Considering these premises, the Spring-Bite device, as described in this paper, may represent a concrete option for rehabilitation in selected patients. The Spring-Bite device may be indicated in those cases where passive mouth opening without an active participation by the patient is requested. In particular, examples of such situation may be found in cases of patients with a reduced muscle force, which prevents them from performing active physiotherapy or passive stretching with currently available devices. For this reason, patients affected by different forms of muscular distrophy may represent the most suitable patient population to introduce the use of such first class lever device in the TMD rehabilitation field.

In the case under description, the Spring-Bite device was used in a patient affected by nemaline myopathy, a severe congenital neuromuscular disease which is characterized by a non-progressive muscular weakness (13). Nemaline myopathy typically affects facial muscles along with the trunk and upper and lower extremities muscles. It was responsible for the patient's facial morphological abnormalities and it should have prevented from achieving a good post-surgical function due to the patient's inability to perform active physiotherapy.

Thanks to the use of this newly introduced device, an acceptable mouth opening was achieved after the orthognathic surgery, and it was mantained over a six-month follow up period.

Such device may also be indicated in all cases of TMJ hypomobility due to muscular trismus and indications for the use of the Spring-Bite device may extend to all the complex post-operatory phases of temporomandibular joint or orthognathic surgeries, which request much attention to allow the patient progressively achieving a normal jaw mobility.

In those cases, a passive motion occurring thanks to an external force the causes movement of the joint

in the absence of muscle activity should be part of the rehabilitation process.

CONCLUSION

The characteristics of the Spring-Bite, which is a first class lever device to perform passive jaw motion rehabilitation at constant load, make this device mainly indicated in some categories of selected patients, such as non-collaborating or dystrophic patients, and in cases of subjects undergone temporomandibular joint or orthognathic surgery.

Future clinical studies are requested to get deeper into the study of indications and effectiveness of the Spring-Bite device.

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