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MEASUREMENT OF OCCLUSAL FORCES IN THE THERAPY OF FUNCTIONAL DISORDERS WITH THE USE OF BOTULINUM TOXIN TYPE A

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Functional disorders of the stomatognathic system include dysfunctions leading to pathological increase of the occlusal forces generated by mandibular adductors. High values of these forces are the cause of numerous disorders within the masticatory organ such as pathological abrasion of the teeth, tension headaches and pain in the region of the temporomandibular joints. The aim of this study was assessment of occlusal forces in the course of the therapy of painful types of functional disorders with the use of botulinum toxin type A - the drug causing muscle relaxation. The material for the study comprised adult patients aged 24-42 years who presented with a painful type of functional disorders in the University Hospital, Institute of Dentistry Jagiellonian University Medical College in Cracow. The patients were qualified to the study on the basis of the results of specialist functional examination of the masticatory organ in which additionally the VAS (Visual Analogue Scale) was used for pain assessment of the masseters and temporomandibular joints. The measurement of maximal occlusal forces in the examined patients was carried out in all patients in the region of the central incisors and first molars on the both side with the use of a special measuring instrument for dental examination, specially constructed (patent number P 334933). The examinations were performed before the beginning of the treatment, 10 days and 16 weeks after intramuscular administration of botulinum toxin type A at a dosage of 21 mouse units - U for one masseter. The results of the examination of maximal occlusal forces obtained in the first examination, that is, before the beginning of the treatment, markedly exceeded the physiological values. In the control examinations, significant, persistent decrease of the studied forces has been noted.

Key words: bite forces, temporo-mandibular dysfunction, botulinum toxin type A, occlusal forces, masticatory organ, intramuscular injections

INTRODUCTION

Occlusal forces in the stomatognathic system are generated by the mandible adductors, the masseter muscles, temporalis and medial pterygoid. The energy generated by these muscles is transmitted as the pressing force of the mandible through the dental arches onto the skull, towards the cranial vault, where it is dispersed (1). The values of occlusal forces are frequently measured in the region of the central incisors and first molars on both sides of the dental arch with the use of various measuring instruments, gnathodynamometers or tensometric sensors (2). In physiological conditions these forces range between 250 N for the anterior teeth and 350 N for the lateral teeth. In males these values are slightly higher due to the structure of their muscles. The generated forces are influenced by both local and systemic factors (3).

In the course of functional disorders of the masticatory organ with accompanying occlusal parafunctions, excessive and uncontrolled increase in occlusal forces occurs. This exerts a lot of negative effects on the stomatognathic system, such as cracking of the enamel, pathological abrasion, damage of the dental prostheses, pathological overgrowth of the masseter muscles, change of the facial features, excessive loading of the

temporomandibular joints. These symptoms are frequently accompanied by pain and tension headaches.

Prosthetic methods of treatment of these disorders are based on gradual decrease of pathological muscle tension with the use of devices called occlusive bars in combination with adjuvant physiotherapy. The mean time of the use of these bars is several months since alleviation of pain is very slow, which is related to the rate of muscular tension decrease (4).

The use of botulinum toxin type A administered intramuscularly allows rapid (up to several days), partial and temporary blockage of cholinergic conduction, which results in the drop of the tension and decrease of muscular electric activity, leading to the decrease of occlusal forces (5).

The aim of this study was the assessment of the maximal occlusal forces in the therapy of painful types of functional disorders with the use of botulinum toxin type A - a muscle relaxant. Botulinum toxin type A is a polypeptide neurotoxin obtained from bacteria *Clostridium botulinum* accessible on the market under the brand name of Botox (of the firm Allergan Inc.). For the first time this drug was registered in Poland and allowed for trade in 1996 with the registration number 6748. This medication is used in many branches of medicine: neurology, ophthalmology, nephrology, orthopaedics, plastic surgery and aesthetic medicine (5-7).

MATERIAL AND METHODS

Agreement of Bioethics Committee No: KBET/96/B/2007.

The material for the study comprised 20 patients aged 24-42 years (4 males and 16 females) who presented with a painful type of functional disorders accompanied by occlusal parafunctions in the University Hospital, Institute of Dentistry Jagiellonian University Medical College in Cracow. The patients were qualified to the study group on the basis of the results of specialist functional examination of the masticatory organ in which additionally the scale for pain assessment of the masseters and the temporomandibular joints VAS (Visual Analogue Scale) was used.

Specialist functional examination and measurement of occlusal forces were carried out three times: before the drug administration, after 10 days when the drug action was maximal, and 20 weeks after intramuscular drug administration, that is, after the cessation of drug action.

Botulinum toxin type A was administered intramuscularly in the site of the largest transverse cross-section of the masseter muscles, in triangle apex projection at a distance of 1.5 cm between each apex, at a dosage of 21 mouse units U for each masseter. Unit (U) is a mean lethal dose administered intraperitoneally which is required to cause death (within 3-4 days from its administration) of 50% of a group of female mice line Swiss-Webster, weighing 18-20 g (5).

Measurements of maximal occlusal forces in all the examined patients were carried out in the region of the central incisors and first molars on the right and left sides (*Fig. 1*), using a special measuring device, constructed for the purpose of dental examinations in the Chair of Mechanics of Technology and Plastic Processing at Silesian Technical University in Katowice

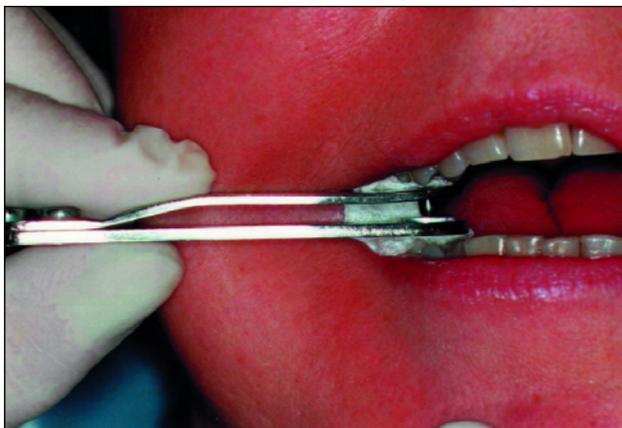


Fig. 1. Measurement of occlusal forces in the region of molar teeth.

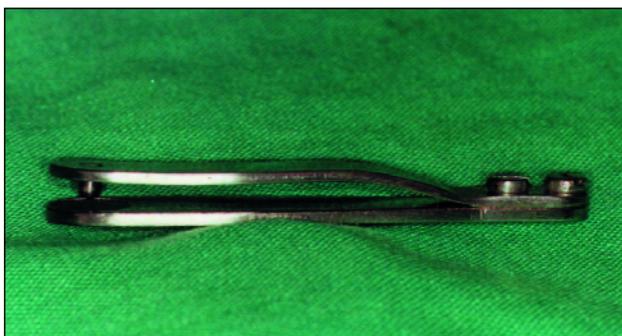


Fig. 2. Measuring device for assessment of occlusal forces in the oral cavity.

(patent number P 334933). This device consists of two plates made of stainless steel 1.5 mm thick, connected with screws (*Fig. 2*). The terminal part of the upper plate contains the so-called penetrator 3.0 mm in diameter, and the lower plate contains a depression which is a bearing for disposable oval aluminium plates 10 mm in diameter (*Fig. 3*). The patients were examined in a sitting position without back rest. They had been instructed about the course of examination and the extent of lowering of the mandible, to the position where adduction starts, that is, about 20 mm. For calculation of maximal values of occlusal forces in this method, Mayer's formula was used. This formula determines the relation of the size of the formed indentation to the force indenting the penetrator, which is the pressing force of the teeth on the measuring device.

Mayer's formula:

$$F=c \cdot d^n$$

c = material constant; d = diameter of depression on the aluminium plate; n = Mayer's coefficient = 1.706. Constant ' c ' and coefficient ' n ' in the above formula were determined for the series of aluminium plates used in the study on the basis of the measurement of the diameter of the depressions created during calibration of the instrument in a universal durability machine. For the measurement of the diameters of the depressions created on disposable aluminium plates (*Fig. 4*), a stereoscopic measuring microscope was used.

The obtained results have been statistically analyzed involving standard calculations of mean values, mean standard



Fig. 3. Depressions created as a result of action of occlusal forces on disposable aluminium plates.

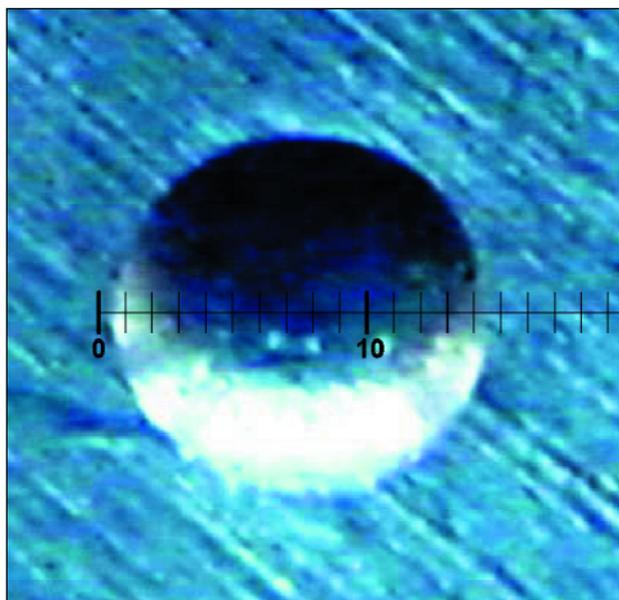


Fig. 4. Measurement of the depression diameter under a stereoscopic microscope.

deviations, minimal and maximal values and variance analysis test for dependent variables and the Tukey's post-hoc test used according to Statistica package.

RESULTS

All the patients underwent specialist dental examinations, aimed at symptoms of functional disorders, on the basis of which the diagnosis of this disease was made. The presenting symptoms of functional disorders which were reported by the patients included: unilateral or bilateral pain in the region of the temporomandibular joints, clicks in these joints during mandible movement, impaired food mastication, sensation of tension or 'blockage' in the temporomandibular joint and restricted opening of the mouth. The pain occurred spontaneously at various times of the day during mandibular movement, food mastication, clenching of the teeth and during palpation of the region of the temporomandibular joint. The pain was localized in the temporomandibular joints and/or it radiated towards the temples and other regions of the head. Apart of these symptoms the patients reported tension headaches and the sensation of 'clogging' of the ears.

The range of abduction of the mandible in three patients diverged from physiological norms, as was decreased to 28.0-33.0 mm. The assessment of the path of abduction and adduction of the mandible showed abnormalities in its medial and terminal phase. The measurement of the resting fissure revealed its diminished size in four patients. The assessment of occlusion included intra-oral examination of the contact of the teeth. Abnormal occlusion was observed in both central and retrocentral occlusal areas in 15 patients.

Palpation revealed pain which was most frequently localized within the masseter muscles, anterior part of the temporal muscles and posterior bellies of the biverter muscles. Totally, 16 patients reported pain on palpation of these muscles. In all the patients, increased tension of the masseters and the temporal muscles was noted, and in 2 patients unilateral overgrowth of masseters was found. In 4 patients the pain radiated to the temporal region. The

temporomandibular joints were both palpated and auscultated. The pain caused by pressure in the region of these joints was noted in 8 patients. Returning clicks were audible in 7 patients (bilaterally in five patients, unilaterally in two patients). Radiography showed in 6 patients irregular spatial arrangement of the joint fissure; in the remaining patients radiological pictures of the temporomandibular joint were normal.

Follow-up examinations carried out several times: before drug administration, after 10 days, and after 20 weeks following intramuscular administration of botulinum toxin type A, revealed considerable decrease of pain in the region of the temporomandibular joints and the masseter muscles. In 14 patients improvement of the symmetry of mandibular movement was observed, and in 4 patients, with prior limitation of jaw opening, the range of abduction of the mandible reached physiological values. In 2 patients palpation evoked pain, but its intensity was markedly lower in comparison with the pain in the first examination (before injection of Botox). Acoustic symptoms remained in 3 patients.

The results of the measurement of maximal occlusal forces in the region of incisors and first molars on both sides, indicate considerable excess of physiological values (*Table 1*). Analysis of mean values of occlusal forces in the area of incisors showed decrease of these values after administration of the drug. The mean value of these forces obtained in the first examination (before the treatment) was 408.48 N (ranging between 189.3 and 647.8 N). After 10 days, the greatest decrease in occlusal forces was observed; significant effects were noted after 20 weeks, that is, in the third examination as it was the period of cessation of the drug action, and occlusal forces were higher as compared to the results of the second examination - 271.9 N (ranging between 114.8 and 396.8 N) - the difference between the values obtained in the first and third examination was 137 N. The mean value of maximal occlusal forces in the region of first molars on both sides was 720 N (725.6 N on the left side and 720.4 N on the right side). The mean value of the third examination, that is, after 20 weeks from drug administration decreased by 300 N (402.33 N on the left side and 437.53 N on the right side).

Table 1. Mean values of occlusal forces obtained in consecutive examinations, standard deviation, minimal and maximal values.

| Mean values of occlusal forces in N (n = 20) | | | |
|--|--|--|--|
| time of assessment | Incisors $\bar{x} \pm s$ [min-max] | Molars L $\bar{x} \pm s$ [min-max] | Molars R $\bar{x} \pm s$ [min-max] |
| before treatment | 408,07±125,56 [189,3–647,8] | 725,69±186,51 [277,8–1026,8] | 720,44±218,96 [86,7–976,7] |
| 10 days after drug administration | 173,75±68,50 [58,2–286,9] | 340,07±97,68 [129,5–472,7] | 375,36±78,97 [197,50–496,7] |
| | 271,92±90,01 [114,8–396,8] | 402,33±84,36 [244,8–532,4] | 437,53±64,99 [270,8–538,8] |

Table 2. Assessment of variances for repeated measurements and the Tukey's post-hoc test.

| Assessed feature | Before drug administration | 10 days after drug administration | 20 weeks after drug administration | Value of F test and level of p sensitivity |
|---------------------|----------------------------|-----------------------------------|------------------------------------|--|
| | $\bar{x} \pm s$ | $\bar{x} \pm s$ | $\bar{x} \pm s$ | |
| Incisors | 408,07±125,56 | 173,75±68,50 | 271,92±90,01 | F=109,65 p=0,0000 |
| Molars – left side | 725,69±186,51 | 340,07±97,68 | 402,33±84,36 | F=127,77 p=0,0000 |
| Molars – right side | 720,44±218,96 | 375,36±78,97 | 437,53±64,99 | F=43,18 p=0,0000 |

Statistical analyses of the results of the examinations indicate that the differences in the values of occlusal forces obtained for all the groups of teeth, and at all time periods are statistically significant $p < 0.005$.

Generally, the results of the studies confirm positive effect of botulinum toxin type A on decreasing high values of occlusal forces generated in the stomatognathic system in patients with functional disorders.

DISCUSSION

Assessment of the effectiveness of the studied drug involved the comparison of the results of functional examination and the values of occlusal forces measured in the region of central incisors and first molars. The results of follow-up examinations allowed to assess the decrease of high values of occlusal forces after administration of botulinum toxin type A. Follow-up examinations revealed decrease of pain within the masseter muscles and the temporomandibular joints, improvement of symmetry of mandibular mobility, lack of painful response of the joints and muscles to palpation, decrease of muscular tension assessed by palpation.

The studies by other authors demonstrated the effectiveness of botulinum toxin type A in the therapy of masseter overgrowth (8-14) and in prosthetic therapy of bruxism (15, 16). Hyperactivity of these muscles is related to long-term excessive muscle tension or excessive exercising leading to muscular overgrowth and overload especially in obese individuals (14). Positive effects were also observed in the treatment with botulinum toxin type A of functional disorders assessed by electromyographic measurements of the masseter muscles and the anterior part of the temporal muscles (15-18).

CONCLUSIONS

1. Taking into consideration harmful effects of the excessive occlusal forces occurring in functional dysfunction of the stomatognathic system, the search for new methods aiming at the decrease of these forces to their physiological level is justified.

2. The administration of testing drug Botox by intramuscular injections causes the decrease of occlusal forces in the therapy of functional disorders of the masticatory organ, leading to cessation of symptoms and improvement of parafunctional symptoms of dysfunction of the masticatory organ.

Conflict of interests: None declared.

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