

The relationship between unilateral mandibular angle fracture and temporomandibular joint function

Ausra Baltrusaityte, Algimantas Surna, Gaivile Pileickiene, Ricardas Kubilius, Alvydas Gleiznys, Juozas Zilinskas

SUMMARY

Purpose. Aim of this study was to analyze relation of occlusal correction and alterations of temporomandibular joint function during treatment of unilateral mandibular fractures.

Materials and methods. We compared 49 patients treated for unilateral mandibular fracture without occlusal correction with 21 patient treated for unilateral mandibular fracture along with early and consequent occlusal analysis and correction and with 49 control subjects. Patients' complaints, mandibular movements and occlusal parameters were evaluated during the period of healing. ZEBRIS ultrasound system (Jaw Motion Analyzer, Zebris Medical GmbH, Isny, Germany) was used for analysis of mandibular movements and T-Scan analyzer (Tekscan, Inc., Boston, MA, USA) was used for occlusal analysis.

Results. Findings of our study showed statistically significant ($p < 0.05$) diminution of patients complaints, mandibular movement alterations and occlusal disturbances in patients who received occlusal correction during MF treatment if compared to patients treated without occlusal correction, except noises from the joint in the injured side and mandibular lateral track to the injured side in the final stage of investigation. Despite applied treatment recovery of the TMJ function was not complete and the investigated parameters remained worse if compared to the control group.

Conclusions. Results of this study confirmed positive influence of early and subsequent occlusal analysis and correction during stages of MF treatment on diminution of functional alterations of the temporomandibular joint function. Timely occlusal correction improves and hastens process of rehabilitation therefore it is indispensable part of MF treatment.

Key words: mandibular fractures, occlusion, articulation.

INTRODUCTION

Due to specific anatomical structure mandibular fractures (MF) are almost always characterized by changes in articulation, chewing function and speech during the process of healing and rehabilitation (1-4). Whereas the TMJ dysfunction has multifactorial etiology, it's diagnostic and treatment remains one

of the most complicated fields of odontology (5). It was stated that prevalence of the TMJ dysfunction of non-traumatic origin range from 27.5 to 43.3%, while prevalence of traumatic origin TMJ dysfunctions varies from 42.0 to 62.5% (6-8). Some authors emphasized deficiency of adaptive capacity of neuromyogenic process in the stomatognathic system, for example Mc Namara and Tsukiyama stated that occlusal disturbances didn't have significant influence on the TMJ dysfunction because continual adaptive processes run in the human stomatognathic system and they compensate inessential functional disorders (9). Petrosov, Lebedenko, Arutiunov, Slavicek and Cooper concluded that occlusal disturbances are one of the main etiological factors of the stomatognathic system dysfunction of compensated or decompensated type (10-14). Trauma of the stomatognathic system was described as very important etiological factor for development of the TMJ dysfunctions

¹Clinical Department of Dental and Maxillar Orthopaedics, Lithuanian University of Health Sciences, Kaunas, Lithuania

²Department of Maxillofacial Surgery, Lithuanian University of Health Sciences, Kaunas, Lithuania

Ausra Baltrusaityte¹ – D.D.S., assist. prof.
Algimantas Surna¹ – D.D.S., PhD., prof.
Gaivile Pileickiene¹ – D.D.S., PhD., assoc. prof.
Ricardas Kubilius² – D.D.S., Dr. hab. med., prof.
Alvydas Gleiznys¹ – D.D.S., PhD., assoc. prof.
Juozas Zilinskas¹ – D.D.S., PhD., lect.

Address correspondence to Ausra Baltrusaityte: Clinical Department of Dental and Maxillar Orthopaedics, Sukileliu 51, LT- 50106, Kaunas, Lithuania.
E-mail address: ausra.baltrusaityte@gmail.com

due to affected all of three principal components (5, 15-18). In cases of MF etiopathological factors become active and their complex influence on the TMJ dysfunction increases. Experimental studies with animals based on morphohistological analysis of divers location mandibular fractures showed that violated integrity of mandible and its biomechanics always resulted in structural alterations of masticatory muscles which determined development of the articular and muscular dysfunction (3). Timely and complete complex treatment of trauma should assure early diagnostic of risk factors and initial functional disorders, while well-timed correction and rehabilitation of primary disorders can prevent or reduce development of the TMJ dysfunction (19). Clinical studies confirmed that parameters such as area of occlusal contacts and time between the 1st occlusal contact to maximal occlusal contacts between the dental arches reliably describe state of the stomatognathic system's function because they allow to evaluate degree of structural as well as neuromuscular rehabilitation, furthermore, timely control and purposeful correction of alterations are relevant in the process of rehabilitation (20). Healing of affected bony structures after MF is lengthy though early balanced occlusion and purposeful stimulation of masticatory muscles activity during post-operative period not only determine faster regeneration of the stomatognathic system function but has positive effect on bone healing process (21). There is few data about dynamical changes of occlusion and articulation during MF healing as well as about potential of their correction, therefore their investigation during process of active MF healing is relevant.

Aim of this study was to verify the hypothesis if occlusal analysis and corrections during MF healing has significant influence on functional alterations of the temporomandibular joint function. In this study we evaluated alterations in function of the stomatognathic system during healing of MF in two investigative groups composed of persons with unilateral MF treated in periods 2003-2009 and 2009-2011; obtained results were compared with functional parameters of the stomatognathic system of healthy people.

MATERIALS AND METHODS

Subjects

Three groups of investigation were formed in this study. The first group (Group 1) consisted of 49 persons hospitalized in Department of Maxillofacial Surgery, Lithuanian University of Health Sciences,

Kaunas, Lithuania, in period 2003-2008 with diagnosis of unilateral mandibular angle or ramus fracture, 37 men and 12 women age 30.88 ± 2.728 . Criteria of inclusion in this study were: 1) Inhabitant of Lithuania which understands Lithuanian language; 2) Person with diagnosis of unilateral mandibular angle or ramus fracture; 3) Person with complete dental arches; 4) Person agrees to participate in the study; 5) Age 18 and more. Following criteria of exclusion were used in this study: 1) Not inhabitant of Lithuania or does not understand Lithuanian language; 2) Person does not agree to participate in the study; 3) Obvious mental or physical disability limiting participating in the study; 4) Other acute or chronic disease aggravating patient's state; 5) Person is younger than 18; 6) Person with incomplete dental arches. In Group 1 there were 35 MF without and 14 with dislocations during trauma. 21 people get treatment with Kirschner wire osteosynthesis and maxillomandibular fixation (MMF) with individual wire splinting, while 28 get only maxillomandibular fixation (MMF) with individual wire splinting. Any occlusal correction was applied for the Group 1 patients. The second group (Group 2) consisted of 21 persons hospitalized in Department of Maxillofacial Surgery, Lithuanian University of Health Sciences, Kaunas, Lithuania, in period 2009-2011 with diagnosis of unilateral mandibular angle fracture, 17 men and 4 women 27.05 ± 3.853 . In Group 2 there were 15 MF without and 6 with dislocations. 14 people were treated by only maxillomandibular fixation (MMF) with individual wire splinting while 7 were treated with Kirschner wire osteosynthesis and maxillomandibular fixation (MMF) with individual wire splinting. Occlusal correction was performed in four stages during healing for all the persons of Group 2. The control group (Group K) consisted of 49 healthy persons, 35 men and 14 women age 33.08 ± 5.024 characterized by physiological types of bite, without trauma of stomatognathic system and without any complains related to the TMJ dysfunction.

Clinical evaluation

In all three groups there were evaluated: complaints of the patients such as pain in the region of TMJ, limitations of the mandibular movements, deviations (single or double) and noises from the joint during mandibular movements as well as parameters of mandibular movements (articulation) and dynamic analysis of occlusion.

Articulation analysis

Articulation of the mandible was analyzed using ZEBRIS ultrasound system (Jaw Motion Analyzer, Ze-

bris Medical GmbH, Isny, Germany). Following parameters were estimated: amplitudes of spatial pathways of condyles and incisal points, equivalence and rate of the vertical and horizontal movements. Measuring accuracy in region of mandibular incisors was 0.1 mm while in region of condyles 0.2-0.3 mm (22).

Occlusal analysis

Dynamic occlusion analysis was performed with T-Scan analyzer (Tekscan, Inc., Boston, MA, USA) using two modes of time and force analysis, there were evaluated locations of occlusal contacts, their active areas, shapes, occlusal balance between intact and injured sides, time between the 1st occlusal contact to maximal occlusal contacts and alternations of bite force balance in time (23-25).

Plan of the investigation

Analysis of the Group 1 and Group K was performed once during the control examination.

Course of the complex examination of Group 2 consisted of 6 stages:

I stage – investigation before immobilization (first day after injury);

II stage – investigation along with the occlusal correction (just after removal of MMF);

III stage – investigation along with the occlusal correction (1 month after removal of MMF);

IV stage – investigation along with the occlusal correction (3 months after removal of MMF);

V stage – investigation along with the occlusal correction (6 months after removal of MMF);

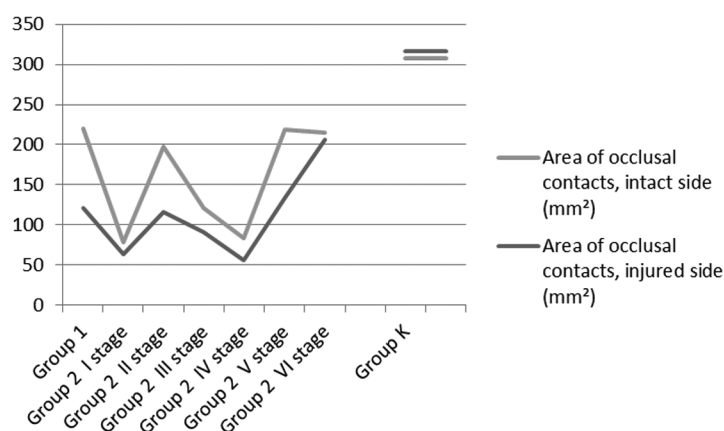
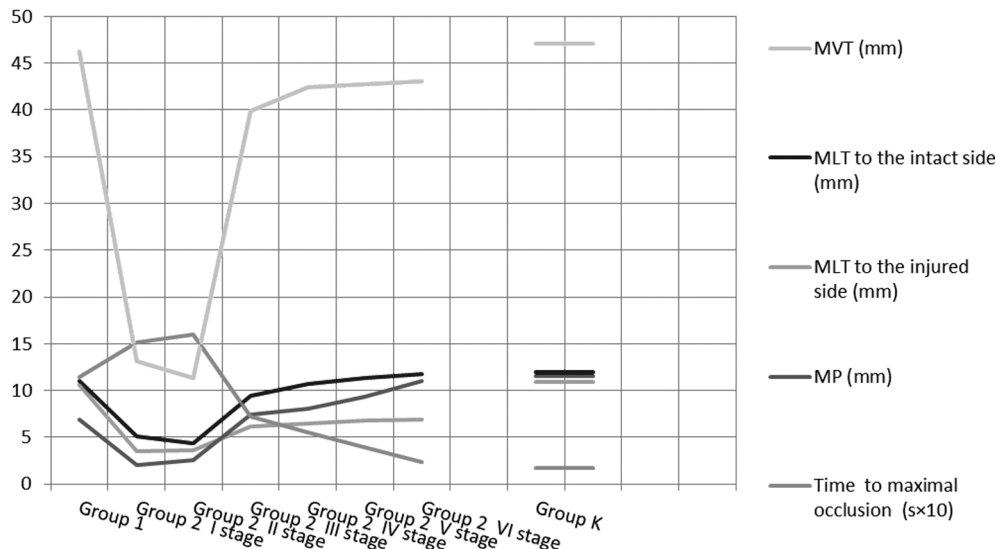


Table 1. Findings of clinical evaluation of patients' complaints in all stages of investigation

Group K n=49	Group 1 n=49	Group 2 n=21 I stage	Group 2 n=21 II stage	Group 2 n=21 III stage	Group 2 n=21 IV stage	Group 2 n=21 V stage	Group 2 n=21 VI stage	Group K n=49
Pain in the region of TMJ	0	8 (16.3%)	18	0	0	1 (5%)	2 (9.5%)	2 (9.5%)
Limitations of the mandibular movements	0	31 (63.3%)	21 (100%)	21 (100%)	9 (43%)	8 (38%)	7 (33%)	5 (23.8%)
Deviation (single/double)	0	49 (37/12) 100%	19 (90%)	0	4 (19%)	4 (19%)	4 (19%)	4 (4/0) (19%)
Noises from the joint	I – 0 T – 0	I – 13 (26.5%) T – 13 (26.5%) IT – 10 (20.4%)	I – 0 T – 0	I – 0 T – 0	I – 0 T – 2	I – 1 (5%) T – 4 (19%)	I – 2 (9.5%) T – 5 (24%)	I – 2 (9.5%) T – 6 (28.5%) IT – 0

VI stage – evaluation of patients complains along with the occlusal analysis (12 months after removal of MMF).

Statistical analysis was performed using program SPSS 22.0 by Student t test and paired t test if the values showed a normal distribution and by Mann-Whitney U test and Wilcoxon signed rank test if the values did not show a normal distribution. Significance was defined as P less than 0.05 for all analyses.

RESULTS

Findings of patients' clinical evaluation in our study showed significantly ($p < 0.05$) higher rate of all complaints in Group 1 if compared to Group 2 in the final stage of investigation except noises from the joint in the injured side (Table 1). Results of mandibular movement analysis in this study showed statistically significant ($p < 0.05$) improvement of all parameters in Group 2 except MLT to the injured side if compared to the Group 1 (Table 2). Findings of occlusal analysis in present study displayed that in the VI stage of investigation all occlusal parameters in Group 2 improved significantly ($p < 0.05$) if compared with Group 1 nevertheless parameters of Group 2 stayed significantly ($p < 0.05$) lower than the

Group K findings (Table 2). Comparative diagram of mandibular movements dynamic during the healing is presented in Figure 1. Dynamical changes of occlusal contacts areas during all the stages of investigation are presented in Figure 2.

DISCUSSION

Function of the human temporomandibular joint (TMJ) is determined by following three principal components: occlusion between the dental arches, structure of the TMJ and the neuromuscular system, responsible for performance and control of the function. American Academy of Orofacial Pain (AAOP) classifies TMJ disorders in two groups according to the main etiological factor – disorders of arthrogenic origin (due to the structural changes and functional disorders) and disorders of biopsychosocial and neuromyogenic origin (26, 27). Disorder in activity of even single abovementioned component can start development of the TMJ dysfunction (28). However, influence of every component is rated differently in discussions; for example, coefficient of occlusion between the dental arches influence on the TMJ pathology is significantly lower than the arthrogenic or biopsychosocial and neuromyogenic origin alteration's influence (26).

Table 2. Findings of mandibular movements and occlusal analysis in all stages of investigation

	Group K n=49	Group 1 n=49	Group 2 n=21 I stage	Group 2 n=21 II stage	Group 2 n=21 III stage	Group 2 n=21 IV stage	Group 2 n=21 V stage	Group 2 n=21 VI stage
Maximal vertical track (MVT) of mandibular incisors (mm)	47.08±6.7	46.21±4.44	13.17±6.24	11.34±2.83	39.93±2.34	42.41±2.09	42.73±1.8	43.11±1.74
Maximal lateral track (MLT) of mandibular incisors to the intact side (mm)	10.76±2.15	11.0±2.62	5.07±2.43	4.36±1.4	9.45±1.0	10.72±1.12	11.37±1.24	11.6±1.2
Maximal lateral track (MLT) of mandibular incisors to the injured side (mm)	10.93±1.7	12.59±2.35	3.5±2.1	4.92±2.76	9.64±1.3	10.93±1.29	11.59±1.29	11.71±1.31
Maximal protrusion (MP) (mm)	9.94±1.16	6.86±2.04	2±0.89	2.57±0.68	7.48±0.75	8.05±0.8	9.29±0.9	11±1.22
Relation of occlusal balance (ROB) between the intact and injured sides (%)	49.69±1.79/ 49.36±1.75	47.79±8.39/ 51.82±7.97	60.11±18.47/ 39.88±18.45	50.81±8.59/ 49.19±8.59	47.74±2.19/ 52.22±2.2	45.91±3.41/ 54.09±3.41	48.06±2.83/ 51.98±2.78	49.61±1.43/ 50.39±1.43
Time between the 1st occlusal contact to maximal occlusal contacts (s)	0.17±0.02	1.14±0.41	1.52±0.69	1.604±0.409	0.722±0.167	0.553±0.173	0.396±0.139	0.24±0.09
Area of occlusal contacts (intact/injured sides) (mm ²)	308.79±1.00/ 316.47±0.76	220.71±5.19/ 121.39±2.04	79.34±3.74/ 64.92±1.39	198.52±4.56/ 116.13±2.53	121.34±2.4/ 91.23±4.21	84.04±13.42/ 56.23±3.42	219.08±2.37/ 134.33±2.1	215.08±7.44/ 206.13±4.51

Clinical studies on patients with MF during period of healing and rehabilitation showed typical disorders related to the masticatory muscles activity: limitations of mandibular movements during opening, protrusive and lateral movements, asymmetric opening movement, pain in the masticatory muscles during palpation and function, asymmetry of the face. All of those disorders described articular – muscular dysfunction and were found in up to 97.3% cases of MF (4). It was stated that one of the main factors for successful treatment of various location MF is proper immobilization of the fragments. There are two basic groups of immobilization techniques in contemporary traumatology – the external and internal (29, 30). Complete immobilization of mandible during treatment of MF is impossible due to obstruction of the vital functions. Partial immobilization with partial restoration of integrity and anatomical shape of the broken mandible as well as pain and biopsychosocial factors disorganize coordinated activity of stomatognathic system's muscles, optimal occlusal contacts between teeth and full-rate chewing (31, 32). In cases of non-complicated unilateral linear MF with adequate fixation bone integrity and function regenerates in 4-5 weeks. Complicated multiple fractures of mandibular ramus and condyle determine complex morphological and functional disorders. Biopsychosocial and neuromyogenic factors get activated during healing and rehabilitation of MF and development process of the TMJ dysfunction assumes long-term multifactorial character (4, 31-34). Analysis of literature concerning the course of MF healing showed that the most of them were concentrated on optimization of the method of immobilization (29, 35-38) but only few studies mentioned meaning of the rehabilitation means during healing stages of MF (39, 40). Fundamental of the external immobilization is to eliminate mobility of the fragments without surgical intervention. External devices (splints) are fixated to the teeth of the injured and antagonistic jaw. Action of the fixating splint is transferred to the jaw bone through soft tissues and periodont. In such circumstances there is no guarantee that the primary repositioning of the fragments will remain during all the period of immobilization (41). Results of the studies concerned to the efficiency of the immobilization showed that inflammatory complications of MF were more frequent and heavier when internal techniques of fixation were used (42, 43) however from the perspective of occlusal rehabilitation wire splinting did not warrant stable position if compared with immobilization based on the orthodontic means or mini-implants (43, 44). Despite there are many

methods proposed for the fragments fixation number of complications such as wrongly concrescence of fragments or post-traumatic osteomyelitis remains quite high (1, 45). The truth is that not all the authors qualify occlusal disturbances as complication (39). Timely and purposeful treatment of any location MF is relevant and efficient for prevention of possible dysfunctions of the TMJ and has significant influence on further course of rehabilitation and its results (45). Obligatory condition for valuable healing of the bone is to ensure good nutrition of the surrounding tissues and proper oxygenation (46), but immobility of both jaws for 4 to 5 weeks worsen these conditions significantly. Early use of the physical exercise can ensure abovementioned conditions (37). Therapeutic exercise in the early post-operative period determine faster psychological adaptation of the patient, improves breathing and hasten processes of metabolism (47). However some of the authors stated that early physical exercise must be avoided when external methods of fragments fixation are used considering maintenance the stability of MMF (38). If internal means of fixation such as osteosynthesis are used stability of fragments is ensured theoretically but broad use of functional exercise is not recommended either due to incomplete investigation of the interaction between bone and osteosynthesis plate. When conservative treatment of MF is applied hypokinesia and hypodynamics dominate (36). Such situation discourages process of stomatognathic system rehabilitation and may become the reason of occlusal alterations and dysfunction of the TMJ. Earlier studies emphasized significance of early occlusal analysis and correction on the prophylaxis of the TMJ disorders (3, 48). In our study we showed dynamics of the functional changes during the healing process as well as positive influence of the early and subsequent corrective treatment on the TMJ dysfunction prevention.

CONCLUSIONS

As a result of MF function of the stomatognathic system is disturbed essentially. Timely diagnostic of alterations and their purposeful correction stimulates course of neuromyogenic adaptive processes and supports compensation of developing dysfunctions of the TMJ. Optimal treatment of MF must take such course: accurate reposition of the fragments, stable fixation, assurance of function, timely removal of the splints, occlusal balancing in stages and individually formed program of rehabilitation to restore the function of masticatory muscles and coordination of the TMJ movements. Findings of

our study showed statistically significant ($p < 0.05$) influence of early and subsequent occlusal analysis and correction during stages of MF treatment

on diminution of functional alterations of the stomatognathic system, consequently, on the TMJ dysfunction formation

REFERENCES

- Efimov JV [Mandibular fractures and their complications (clinical and experimental studies) [summary of dissertation.] Moskva; 2004. Rus.
- Lepilin AV, Konnov VV, Bagaryan EA, Arushanyan AR Clinical manifestations of pathology of the temporomandibular joints and masticatory muscles in patients with impaired occlusion of teeth and dentition. *Saratov J Med Sci Res* 2010;6:93-5.
- Bagautdinova VI. [Impaired function of the temporomandibular joints in fractures of the lower jaw of various localization and correction methods (clinical and experimental studies) [summary of doctoral dissertation]. Moskva; 2004. Rus.
- Lepilin AV, Konnov VV, Bagaryan EA, Batusov NA Functioning of masticatory muscles in patients with fractures of lower jaw. *Saratov J Med Sci Res* 2012;8:108-111.
- Okeson Jeffrey P. Management of Temporomandibular Disorders and Occlusion. Elsevier Health Sciences; 2007.
- Giannakopoulos HE, Quinn PD, Granquist E, Chou JC. Posttraumatic temporomandibular joint disorders. *Cranio-maxillofacial Trauma Reconstr* 2009;2:91-101.
- Stegenga B., de Bon LG. M., Boering G. Temporomandibular joint pain assessment. *J Orofac Pain* 1993;7:23-37.
- Pullinger AG, Seligman DA. Trauma history in diagnostic groups of temporomandibular disorders. *Oral Surg Oral Med Oral Pathol* 1991;71:529-34.
- Klineberg I., Jagger R. G. Occlusion and clinical practice : an evidence-based approach. Elsevier - Health Sciences Division; 2004.
- Dolgolev AA, Bragin EA. [Comprehensive examination and treatment of patients with disorders of occlusion]. *Stomatologija (Mosk)* 2007;7:17-20. Rus.
- Lebedenko II, Arutiunov SD, Antonik MM, Sputnikov AA. [Clinical methods of diagnosis of functional disorders of dental system]. Moskva; 2006. Rus.
- Cooper BC, Kleinberg I. Establishment of a temporomandibular physiological state with neuromuscular orthosis treatment affects reduction of TMD symptoms in 313 patients. *Cranio* 2008;26:104-17.
- Slavicek R. Relationship between occlusion and temporomandibular disorders: implications for the gnathologist. *Am J Orthod Dentofac Orthop.* 2011;139:10-4.
- Wang C, Yin X. Occlusal risk factors associated with temporomandibular disorders in young adults with normal occlusions. *Oral Surg Oral Med Oral Pathol Oral Radiol* 2012; 114:419-23.
- Egorov PM, Karapetian IS. [Painful dysfunction of the temporomandibular joint]. Moskva; 1986. Rus.
- Petrosov JA. [Orthopaedic treatment of dysfunctional syndromes arthritis and arthrosis of the temporomandibular joint (clinical and experimental studies)[summary of doctoral dissertation]. Krasnodar; 1982. Rus.
- Chvatova VA [TMJ diseases and treatments]. *Stomatologija (Moskva)* 1997; 58:22-8. Rus.
- Yun P-Y, Kim Y-K. The role of facial trauma as a possible etiologic factor in temporomandibular joint disorder. *J Oral Maxillofac Surg* 2005; 63:1576-83.
- Bragin EA, Dolgalev AA, Bragareva NV. [Influence of occlusal disorders in disease development TMJ, dysfunction of the masticatory muscles and periodontal disease]. *Sovremennye problemy nauki i obrazovanija*. Rus. [cited 2014-10-15] Available from: URL: <http://www.science-education.ru/pdf/2014/1/115-11219>.
- Murakami K, Yamamoto K, Sugiura T, Yamanaka Y, Kirita T. Changes in mandibular movement and occlusal condition after conservative treatment for condylar fractures. *Oral Maxillofac Surg* 2009;67:83-91.
- Dauletchozaev NA [Treatment of mandibular angle fracture with modern materials] (clinical and experimental studies) [summary of doctoral dissertation]. Almata; 2010. Rus.
- Best N. Untersuchungen zur Reliabilität und Validität der dreidimensionalen. Kiefergelenkfunktionsanalyse mittels Zebris WinJaw-System [dissertation]. [Jena]; 2010.
- Garrido García VC, García Cartagena A, González Sequeros O. Evaluation of occlusal contacts in maximum intercuspation using the T-Scan system. *J Oral Rehabil* 1997; 24:899-903.
- Olivieri F, Kang KH, Hirayama H, Maness WL. New method for analyzing complete denture occlusion using the center of force concept: a clinical report. *J Prosthet Dent* 1998; 80:519-23.
- Suda S, MacHida N, Momose M, Yamaki M, Seki Y, Yoshie H, et al. A multiparametric analysis of occlusal and periodontal jaw reflex characteristics in adult skeletal mandibular protrusion before and after orthognathic surgery. *J Oral Rehabil* 1999;26:686-90.
- Gesch D, Bernhardt O, Mack F, John U, Kocher T, Alte D. Association of malocclusion and functional occlusion with subjective symptoms of TMD in adults: results of the Study of Health in Pomerania (SHIP). *Angle Orthod* 2005;75:183-90.
- Epker J, Gatchel RJ, Ellis E 3rd. A model for predicting chronic TMD: practical application in clinical settings. *J Am Dent Assoc* 1999;130:1470-5.
- Kafas P, Leeson R. Assessment of pain in temporomandibular disorders: the bio-psychosocial complexity. *Int J Oral Maxillofac Surg* 2006;35:145-9.
- Dacko AA, Volozin AI, Tetiuchin DV. [Extrafocal osteosynthesis in the treatment of lesions of the mandible]. *Prakticeskaja medicina*; 2005. Rus.
- Dacko AA, Tetiuchin DV. [Implementation of modern principles of treatment of injuries of the maxillofacial region.] *J. Stomatologija (Mosk)* 2003; 82:17-21. Rus.
- Choi BH, Kim KN, Kang HS. Clinical and in vitro evaluation of mandibular angle fracture fixation with the two-miniplate system. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 1995;79:692-5.
- Feller KU, Richter G, Schneider M, Eckelt U. Combination of microplate and miniplate for osteosynthesis of mandibular fractures: an experimental study. *Int J Oral Maxillofac Surg* 2002;31:78-83.
- Konnov VV, Googe LA, Razakov DH Lechenie dis funkcii visochno-nizhnecheljustnogo sustava. [Sovremennye problemy organizacii i okazanija specializirovannoj medicinskoj pomowi: sb. nauch. tr. Saratov]; 2005. Rus.
- Konnov VV, Razakov DH, Karcev GA. Lechenie dis funkcii visochno-nizhnecheljustnogo sustava. [Zdorov'e i obrazovanie v XXI veke: mater. 6-j mezhdunar. nauch.-prakt. konf. Moskva]; 2005. Rus.
- Adnan Ali Shah, Abdus Salam. Pattern and management of mandibular fractures: a study conducted on 264 patients. *Pak Oral Dent J* 2007;27:103-5.
- Baikirov IM, Imbriakov KV, Savelev AD, Samutkina MG, Fisher II [Rehabilitation of patients with traumatic disease

- in fractures of the mandible]. *Stomatologija (Mosk)* 2011; 1:61-6. Rus.
37. Matveeva AI, Frolov VA, Gvatadze RS. [Influence of parameters of the implant on the stress-strain state of bone]. *Stomatologija (Mosk)* 2010;5:63-5. Rus.
38. Pankratov AS, Robustova TG, Prityko AG. [Theoretical and practical substantiation methods of surgical treatment of patients with mandibular fractures and complications]. *Ross Stomatol Zh* 2005;1:42-5. Rus.
39. Savelev AL. [Rationale for use therapeutic gymnastics in the early postoperative period in patients with mandibular fractures]. [cited 2014-10-15] Available from: <http://www.science-education.ru/102-6008>. Rus
40. Khuman R, Chavda D, Surbala L, Chaudhary E, Bhatt U, Nambi G. Physical therapy in temporomandibular dysfunction following maxillo mandibular fixation in subcondylar mandibular fracture a single case study. [cited 2014-10-15]. Available from: <http://www.scopemed.org/?mno=45099>
41. Mitrosenkov PN. [Reconstructive surgery of total and subtotal defects upper, middle and lower zones of the facial skeleton]. Moskva; 2010. Rus.
42. Razukevičius D. Studies on the diagnostics of mandibular angle fractures, their clinical peculiarities and the effectiveness of treatment [summary of doctoral dissertation]. Kaunas, 2005.
43. Fan Zhang, Yuan Yi, Trofimov IG., Khatstkevich GA. [Comparative analysis of treatment outcomes of patients with mandibular fractures with different methods of gentle immobilization of bone fragments]. *Institut Stomatologii (Sankt Peterburg)* 2012;2(55):82-3. Rus.
44. Baltrusaityte A, Surna A, Pileicikiene G, Kubilius R, Gleiznys A, Baltrusaitis M. Dynamical changes of occlusion and articulation during treatment of mandibular angle fractures. *Stomatologija*. 2013;15:12-9.
45. Bagautdinova VI, Agapov VS. [Effect of chronic musculo-articular disorders, previous injury, for a fracture of the mandible]. *Institut Stomatologii (Sankt Peterburg)* 2002; 4:24-7.
46. Vavilova TP. [Biochemistry tissue and fluids of the oral cavity] Moskva; 2011. Rus.
47. Afanasev VV. [Trauma of maxillofacial area] Moskva; 2010. Rus.
48. Isakov IR. [Early diagnosis and correction of occlusion and dysfunction of the temporomandibular joint in secondary displacement of the mandible] (clinical and experimental studies) [summary of doctoral dissertation]. Ufa; 2012. Rus

Received: 08 07 2014

Accepted for publishing: 26 09 2014