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Comparative Analysis of the effectiveness of the mandibular angle fracture treatment methods

Dainius Razukevičius, Gintautas Sabalys, Ričardas Kubilius

SUMMARY

425 patients with mandibular angle fractures were treated at the Hospital of Kaunas University of Medicine (HKUM) Clinic of Maxillo-Facial Surgery. Treatment included the application of closed fracture fragments fixation methods (wire splint fixation, and Kirschner wire osteosynthesis), and methods of open fixation - osteosynthesis using the supra-periosteal miniplate, and osteosynthesis using supra-osseous Zes Pol plate (the latter method was modified by the authors). Relative computerized densitometry showed that closed fixation methods result in a faster healing of fractures. The findings of the pain threshold testing showed that open fixation methods more severely damage the function of the lower alveolar nerve. Using closed fixation methods, osteomyelitis occurred in 5.3% of cases, while using open fixation methods – in 15.3% of cases. Thus, the authors of the article maintain that when mandibular angle fractures, in the presence of suitable conditions, closed fracture fragments fixation methods should be given a priority.

Key words: treatment of mandibular angle fractures, damage to n. alveolaris inferior.

INTRODUCTION

Mandibular fractures make ca. 80% of all facial traumas [1], and in 20-30% of cases the fracture occurs in the site of the angle [2, 3]. Certain structural and functional peculiarities - smaller diameter, compared to other sites of the jaws [4], thinner compact bone plate [5], shape changes during life and frequent impacted or nut fully erupted 8th teeth [6,7], bilateral muscle cover, and endo-osseous and extra-osseous blood circulation – condition the peculiarities of the treatment of fractures, and the relevance of their studies, the more as this issue is controversially presented in the literature.

A wide variety of treatment methods have been proposed for the treatment of mandibular angle fractures. However, no comparative analysis of the effectiveness of these treatment methods has been performed, and no concrete indications for the application of these methods have been presented either.

The aim of our work was to study the effectiveness and the advantages of different methods of the treatment of mandibular angle fractures.

MATERIAL AND METHODS

The study included 425 patients with mandibular angle fractures. The patients were examined at the inpatient unit of HKUM Clinic Maxillo-Facial Surgery. 89% of the patients with mandibular angle fractures were males. The majority (64.9%) of them were 15-44 years of age (Table 1).

The effectiveness of the methods of treatment was evaluated according to their influence on the course of the healing of fractures, the functional status of the lower alveolar nerve, and the development of complications. The dynamics of the healing of fractures was evaluated using computerized densitometry, according to the findings of orthopantomography. The influence of the treatment methods on the functional status of the lower alveolar nerve was determined by comparing the pain threshold of the nerve prior to the repositioning and fixation of the fracture fragments, and after it. The pain threshold of the nerve was examined using a self-designed method [8]. The statistical evaluation of the findings was performed with the help of the SPSS (Statistical Package for Social Sciences) software package. Mean (X±Sx) and percentage values were calculated. Statistical hypotheses about the equality of two mean or percentage values were verified using Student's (t) criterion. Kalmogorov-Smirnov test was used to determine the normal distribution of quantitative values.

The level of statistical significance of statistical hypotheses was set at 0.05 (statistically significant).

RESULTS

Fixation of fracture fragments was performed using the following methods: wire splint fixation (115 patients), Kirschner wire osteosynthesis (246 patients) (Fig. 1), osteosynthesis with supra-periosteal miniplate (59 patients) (Fig. 2), and osteosynthesis with Zes Pol plate (5 patients) (Fig. 3). The latter method, known as the method of fixation of long bone fracture fragments with the help of the supra-osseous plate, modified by the authors and applied for the

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Table 1. The distribution of the subjects according to sex and age

Subjects	Sex				Age (years)										Total
	Male		Female		Up to 15		15-44		45-59		60-74		>74		
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	
Patients	678	89	47	11	4	0.9	276	64.9	123	28.9	20	4.7	2	0.4	425

fixation of mandibular angle fracture fragments. The investigation of orthopantomograms with the help of relative computerized densitometry allowed for the evaluation of even minimal changes in the fracture site according to the means of optical densities. The findings of relative computerized densitometry in relation with the methods of the fixation of fracture fragments are presented in Table 2.

The findings presented in the table show that the tendency of the dynamics of changes in the mean values of optical densities following fracture fragments repositioning and fixation is analogous irrespectively of the method applied – during the first two weeks, the means of optical density in the fracture site decreased, while from the third week on they increase and become equal to those in healthy sites of the jaws. However, the degree of the changes in optical densities within the same period of time was dependent on the fracture fragments fixation method. This becomes obvious after the expression of the increase or decrease in optical densities in percent, and the comparison of the results to the findings of a previous study (in the table, the percentage of these changes in given in brackets). During the first week following closed fixation methods (wire splint and Kirschner wire fixation), the means of optic densities in the fracture site decreased by, on the average, 6%, and following open fixation (osteosynthesis using supra-periosteal miniplate or supra-osseous Zes Pol plate) – by, on the average, 12%. The greatest decrease in optical densities was observed during the second week: following closed fixation – by ca. 12%, and following open fixation – by more than 30%. After 4 weeks, the means of optical densities were not significantly greater than those seen on the 14th day of treatment: after closed fixation – by ca. 3%, and after open fixation – by ca. 6%. The greatest increase in optical densities was observed between the 45th and the 60th day after repositioning and fixation. During this period, mean optical densities following closed fixation increased by 15%, and following open fixation – by more than 30%. On the 60th day of the study, mean optical densities in the fracture site following wire splint fixation and Kirschner wire fixation did not differ essentially from those in the healthy site of the jaw ($p>0.05$). There were practically no changes in optical densities during the third month of treatment – the densities increased by ca. 0.6%. 90 days after the repositioning and fixation of fracture fragments, there were no essential differences between mean optical densities in the fractured and the healthy sites in cases of osteosynthesis with supra-periosteal miniplate or Zes Pol plate (the difference was statistically unreliable, $p>0.05$).

The influence of the repositioning and fixation on the functional status of the lower alveolar nerve was judged by the changes in the pain threshold of the damaged nerve after the therapeutic procedure. Repositioning and fixation of fracture fragments in all cases resulted in changes of the pain threshold of the damaged nerve: in cases of mild damage to the nerve, the pain threshold decreases, and in cases of moderate to severe damage – increases. The analysis of the influence of the fracture fragments fixation method on the changes in the functional status of the affected nerve (Table 3) showed that the pain threshold in the site innervated by the lower alveolar nerve changed the least in the result of wire splint or Kirschner wire fixation (closed fixation). Both methods did not differ significantly concerning their influence of on the changes in the functional status of the affected nerve. Changes in the pain threshold of the damaged nerve were significantly

Table 2. Data of relative computerized densitometry with respect to the method of the fixation of fracture fragments

Treatment method	No. of cases	Means of optical densities and the time of the examination after the fixation						
		1 day	7 days	14 days	28 days	45 days	60 days	90 days
Fixation with wire splints	37	0.854±0.016	0.803±0.012 (–6%)	0.702±0.010 (–12.6%)	0.725±0.008 (+3.2%)	0.793±0.022 (+8.6%)	0.932±0.008 (+14.9%)*	0.939±0.005 (+0.8%)*
Ostheosynthesis with Kirschner wire	51	0.853±0.019	0.798±0.014 (–6.5%)	0.699±0.012 (–12.4%)	0.720±0.006 (+2.9%)	0.789±0.024 (+8.8%)	0.937±0.011 (+15.8%)*	0.941±0.009 (+0.5%)*
Ostheosynthesis with the supra periosteal miniplate	26	0.747±0.023	0.651±0.035 (–12.9%)	0.409±0.007 (–37.2%)	0.439±0.012 (+6.8%)	0.498±0.021 (+11.9%)	0.803±0.035 (+38.0%)	0.926±0.030 (+13.3%)*
Ostheosynthesis with the Zes Pol plate	5	0.756±0.020	0.679±0.031 (–10.2%)	0.487±0.008 (–28.3%)	0.519±0.010 (+6.2%)	0.569±0.018 (+8.6%)	0.824±0.029 (+31.1%)	0.937±0.031 (+12.1%)*

The increase (+) or the decrease (–) in optical densities in percent, compared to the previous study, is given in brackets.
* – the difference is statistically unreliable, compared to the healthy site of the jaw, $p>0.05$

Fig. 1. Kirschner wire osteosynthesis

Fig. 2. Osteosynthesis with supra-periosteal miniplate

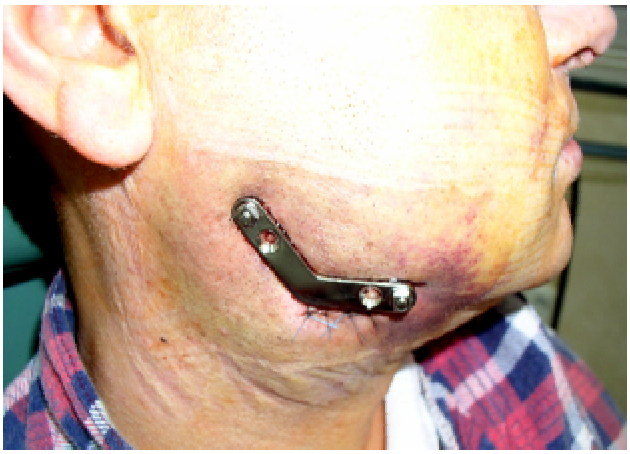

Fig. 3. Osteosynthesis with Zes Pol plate

more prominent following osteosynthesis with supra-periosteal miniplate or Zes Pol plate (open fixation). However, the comparison of the influence of these methods on the functional status of the nerve revealed no significant differences. In addition to that, changes in the pain threshold after treatment were dependent on the degree of the severity of the nerve damage prior to the treatment. In cases of mild or moderate degree of nerve damage, the functional status of the nerve following closed fracture fragments fixation worsened by, respectively, 15.3% and 11.2%, and following open fixation – by 25.6% and 18.1%, accordingly. In cases of severe nerve damage, the functional status of the affected nerve did not change significantly after the fixation.

During the course of the treatment, in 28 patients mandibular angle fractures developed into complications, resulting in osteomyelitis. These patients constituted 6.59% of all the treated patients. The highest percentage of complications was observed among the patients who underwent osteosynthesis with the supra-periosteal plate (Table 4). Cases of osteomyelitis were significantly less numerous among those who underwent fracture fragments fixation with wire splints and Kirschner wire (closed fixation methods). These methods were applied in 361 patients, 19 (5.3%) of which developed osteomyelitis. This means that the application of these methods reduces the probability of the development of osteomyelitis by 3 times, compared to osteosynthesis with a supra-periosteal plate. According to the results of the statistical analysis, osteosynthesis with a supra-periosteal plate is attributed to significant factors related to complications of fractures, resulting in osteomyelitis.

Table 3. The influence of fixation method on the functional status of the lower alveolar nerve

Degree of nerve damage	No. of studied patients	Pain threshold of the healthy nerve	Pain threshold of the damaged lower alveolar nerve, µA				
			Prior to the treatment	After closed fixation	Change in the threshold	After open fixation	Change in the threshold
Mild	31	46.9 ± 3.1	26.8 ± 2.7	22.7± 2.8	15.3	19.9± 2.3	25.6*
Moderate	168	47.3 ± 2.3	59.8 ± 3.3	66.5± 3.7	11.2	70.6± 3.9	18.1*
Severe	89	47.1 ± 3.4	99.7 ± 3.8	102.4± 3.2	2.7	103.1± 4.2	3.4

* The change in the pain threshold is statistically reliably greater, compared to the change following closed fixation

Table 4. Distribution of the cases of osteomyelitis in relation with fixation methods

Method of fixation	No. of treated patients	With osteomyelitis		No. of treated patients	With osteomyelitis	
		n	%		n	%
Wire splints	115	5	4,3	361	19	5,3
Kirschner wire	246	14	5,7			
Plate osteosynthesis	59	9	15,3	59	9	15,3
Zes Pol plate	5	-	-	-	-	-
Total	425	28	6,6	425	28	6,6

DISCUSSION

The application of the relative computerized densitometry method allowed for the objective evaluations of the efficacy of the treatment methods. The study of orthopantomograms, using the means of optical densities, allowed for the evaluation of even minimal changes in the fracture site.

The findings of the study showed that the tendency of changes in the means of the optical densities following the repositioning and fixation of fracture fragments was analogous irrespectively of the used method. Mean values of optical density tended to decrease during the first two weeks. According to the classification of the 4 clinical-roentgenological stages of the healing of mandibular fractures proposed by Korotkina [8], this would correspond to the first stage of healing, which she called roentgen-negative. Starting from the third week, the differences between the means of the optical densities in the fracture site start to increase. However, the increase in the optical densities during the 3rd and the 4th week is slight. This period would correspond to the second – the "soft" callus – stage. The highest increase in optical densities in the fracture site was registered between the 6th and the 8th week following the repositioning and the fixation of fracture fragments, which, according to Korotkina's classification, would correspond to the 3rd stage of healing.

The time when the means of optical densities in the fractured site become equal to those in the healthy site differed with respect to the application of different fixation methods. On the 60th day following wire splint fixation and Kirschner wire osteosynthesis, the mean values of optical densities in the fracture sites did not differ significantly from those in the healthy sites of the jaw ($p>0.05$). In cases of osteosynthesis with the supra-periosteal plate or the Zes Pol plate, no significant differences between the mean values of optical densities (statistically unreliable difference, $p>0.05$) were found after 90 days following the repositioning and fixation of fracture fragments. This means that mandibular angle fractures were roentgenologically diagnosed as healed after 60 days following wire splint fixation or Kirschner wire fixation, and after 90 days following osteosynthesis with supra-periosteal miniplate or the Zes Pol plate.

Solovjov et al [9] and Lindman [10] differentiated two periods of the healing of maxillary fractures – the formation of the primary osseous callus (2-3 weeks after the fracture), and the formation of the secondary osseous callus (6-8 weeks after the fracture). Such course of healing, called the primary type of fracture healing, in our case was observed following fracture fragments fixation with wire splints and Kirschner wire.

Following osteosynthesis with the supra-periosteal plate and the Zes Pol plate, the course of healing was attributable to the primary prolonged type of fracture healing, which is observed in cases when there is no sufficient gap between the firmly fixed immovable fracture fragments, and the resorption of their endings impedes complete inter-medullar adhesion of the fracture fragments [11, 12].

Bilkay et al. [13], using scintigraphy (with the use of Tc 99m methylene diphosphate) proved that the most intensive formation of the callus in case of maxillo-mandibular fixation occurs between the 1st and the 10th day after the operation, and in case of internal fixation) – between the 10th and the 20th day. This shows that minimal mobility of fracture fragments during maxillo-mandibular fixation activates osteogenesis, and the callus forms more rapidly in case of non-stable fixation.

The incidence of complications is one of the criteria of the evaluation of the efficacy of treatment. In cases of mandibular angle fractures, the incidence of complications varies: Feller et al. [14] state that healing complications occur in 2.3% of cases, according to Dhariwal et al. [15], such percentage is 7.3%, Lamphier et al. [16] – 13.3%, Atanasov [17] – 25.2%, etc.. Such huge difference between the findings presented by different authors exists becose some authors attribute bleeding, hematomas, infections, neural damage, and post-operative calluses to complications, while others [18] think that complications include fracture fragments adhesion failure, damage to the lower alveolar nerve, osteomyelitis, and malocclusion.

Osteomyelitis ranks among the most common and most severe complications of fracture healing. According to the findings presented by Fox and Kellman [18], inflammatory complications in cases of mandibular angle fractures amount to 5.9%, and according to Ellis [23] – to 15.8%.

Of 425 treated patient in our study, in 28 (6.6%) of patients the healing of mandibular angle fractures complicated, resulting in osteomyelitis. The analysis of the possibility of various factors for influencing the development of osteomyelitis allowed for the identification of factors that were statistically reliably significant in the complication of fracture healing, resulting in osteomyelitis in our patients. According to the data of logistic analysis, the distribution of these factors according to their significance is the following: non-restored carious teeth and their non-extracted roots; the 8th teeth that had not been removed from the fracture gap; provision of specialized care after 5-7 days; and osteosynthesis with the supra-periosteal miniplate. These findings of our study corresponded to those provided by other authors who investigated the causes of complications of mandibular fractures resulting in osteomyelitis.

Lukjanenko et al. [19] indicated that osteomyelitis develops in 6% of patients if specialized assistance is provided within the first day after the trauma. If such assistance is provided after 7 days, osteomyelitis in cases of mandibular fractures develops in 16-18% of patients.

Robustova [20]. Bažanov [21], and Lukoðiûnas [22] unambiguously state that teeth in the fracture gap are the main factor conditioning the development of traumatic osteomyelitis.

Rudman et al. [24], who during their experiment performed photoelastic analysis of the osteosynthesis of fracture fragments using supra-periosteal miniplate in mandibular angle fracture, and Champ8 [25], on the basis of the clinical study, state that the extensive force used in pressing the plate to the bone with bolts may be the main cause of complications following osteosynthesis.

The indications for the usage of the fracture fragments fixation method were determined according to the following criteria: the type of the fracture, the variant of the fracture, and the necessary conditions for the application of the selected method. When selecting the method of

fracture fragments fixation for an individual patient, these were the first criteria that were evaluated. Most frequently, one of several suitable fixation methods can be selected for concrete types and variants of fractures. In such cases, priority was given to the less traumatic and technically simpler method.

Although recently the majority of authors prefer osteosynthesis with supra-periosteal miniplate [26-28], our results of the comparative analysis of the effectiveness of fixation methods provide a good basis for disagreeing with these authors.

On the basis of the aforementioned arguments, we prefer the application of wire splint and Kirschner wire fixation in the presence of the necessary conditions for the usage of these methods. Since osteosynthesis with supra-osseous Zes Pol plate is less traumatic, compared to osteosynthesis with the supra-periosteal plate, the former one is referred. The correctness of our choice is confirmed by Artiushkevich and Shved [29] who during their experiment determined that the regeneration of the bone proceeds in a more physiological way if biomechanically-based osteosynthesis methods are used, such as osteosynthesis with supra-osseous plates.

CONCLUSIONS

1. Fracture fragments fixation method using wire splints and Kirschner wire (closed fixation methods) are less traumatic than osteosynthesis with supra-periosteal miniplate or Zes Pol plate (open fixation methods).
2. Fractures heal more rapidly following closed fixation methods, compared to open fixation methods, since in the former case reparatory regeneration proceeds according to the primary type. And in the latter case – according to the primary prolonged type.
3. The incidence of osteomyelitis following the application of closed fixation methods is 5.3%, and following the open fixation methods – 15.3%.
4. The repositioning and fixation of fracture fragments using open fixation methods results in higher traumatism of the lower alveolar nerve, compared to the usage of closed fixation methods.

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