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Maxillofacial Injury Severity Score: proposal of a new scoring system

J. Zhang[1], Y. Zhang[1], M. El-Maaytah[2], L. Ma[1], L. Liu[1], L. D. Zhou[1]

[1]Department of Oral and Maxillofacial Surgery, Peking University School of Stomatology, Beijing 100081, PR China; [2]Oral and Maxillofacial Surgery Department, Eastman Dental Institute, University College of London, London, UK

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Abstract. In this study a new injury severity score system, the Maxillofacial Injury Severity Score (MFISS), was developed to evaluate the characteristics of injury from maxillofacial trauma. Nine hundred and two cases of maxillofacial trauma were included in this study to evaluate injury severity using the MFISS, which was designed on the basis of Abbreviated Injury Scale, 1990 revision (AIS-90), and defined as the product of the sum of the three highest maxillofacial AIS scores and the sum of the injury severity scores for three maxillofacial functional parameters, malocclusion (MO), limited mouth opening (LMO), and facial deformity (FD). The correlation analysis was undertaken with the dependent factor of cost and number of days of stay in hospital. The results demonstrated a significant difference ($P < 0.01$) between bone and soft-tissue injuries and among various regional fractures. There was correlation ($P < 0.01$) between the MFISS and the cost of treatment and days of stay in hospital. The newly established MFISS thus characterizes maxillofacial injury severity while reflecting the management costs and treatment complexity.

Key words: maxillofacial trauma; injury severity score.

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In order to assess injury severity and its probable outcome, various trauma scoring systems have been developed over the past decades. The Abbreviated Injury Scale (AIS) was put forward in 1971 and revised repeatedly by The American Association for Automotive Medicine[2]. AIS is a summary of all values from 1 to 9 for each injured organ and body part that has became the groundwork of subsequent scoring standards. Although the AIS can be used to evaluate trauma severity itself, it cannot be employed to predict outcome due to its limitation to only an anatomical description of injury. The Injury Severity Score (ISS), proposed by Baker et al.[3] in 1974, is defined as the sum of the squares of the highest AIS grade in each of the three most severely injured body areas. It has been playing the role of 'standard summary' in trauma measurement for more than 20 years. The Trauma and Injury Severity Score (TRISS)[4] is a trauma score method using a combination of anatomical and physiological criteria, the age of patients, and the mechanism of injury. As well as quantifying injury severity, it can be used to calculate the survival probability of the injured victims and evaluate the emergency management of the hospital[9]. This scoring system obviated the ISS shortcomings.

The New Injury Severity Score (NISS), a modified version of ISS[17], simplified the complexity of ISS calculation and improved its predictive power. The Severity Characterization of Trauma (ASCOT)[8] is actually an upgraded version of TRISS in which the Glasgow Coma Score, systolic blood pressure, and respiratory rate were indexed. A few scoring models were designed for special trauma issues[24], such as Acute Physiology and Chronic Health Evaluation (APACHE) for intensive care, Mortality Probability Models (MPA) for the prediction of trauma death, and the Mathematical Model of Hemorrhagic Shock (MMHS) for triage decisions on hemorrhagic shock[7]. The Pediatric Trauma Score (PTS) was designed for evaluation of the response of pediatric patients to trauma[25].

All these scoring systems are available for the assessment of general trauma, and mainly focus on the prediction of survival or death; they rarely enable the measurement of impairment and disability of the injured organs. In fact, such impairment or disability is very frequent, especially as the outcome secondary to motional organ injury, which can often cause deterioration in quality of life. In hand surgery, the hand injury severity scoring system (HISS)[16] has been developed, taking into consideration the prognostic outcome. Maxillofacial trauma, to some extent, is similar to motional organ injury in the correlation between injury severity and prognosis, rarely leading to a direct threat to life, but often resulting in functional disability. The current scoring models have proved insensitive and inaccurate in judging maxillofacial injury severity for the prediction of prognosis, because the parameters and score indices that they contain are insufficient to reflect the peculiarities of this type of trauma and its outcome. Therefore, the aim of this study was to establish a new scoring system especially designed for maxillofacial trauma.

Materials and methods

The study population consisted of 902 maxillofacial trauma patients treated between 1996 and 2002, 739 (81.9%) male and 163 (18.1%) female, aged 1–87 years with a mean age of 31 years. Of them, 706 (78.2%) were from the Department of Oral and Maxillofacial Surgery, Peking University School of Stomatology, and 196 (21.8%) from another nine oral and maxillofacial units of state general hospitals distributed in four provinces.

All patients included in this retrospective study fulfilled the following criteria: (1) there was a definite diagnosis of maxillofacial trauma and detailed description of the physical examination; (2) treatment was available within 2 weeks of the trauma incident. Of the 902 patients, 613 (68.0%) underwent surgical treatment and 289 (32.0%) were treated by conservative methods. Their documents containing the records of trauma cause, injury sites, and severity description, associated body injuries, treatment cost, and hospitalization days were collected and stored using specially designed analysis software. The initial diagnosis of maxillofacial injury was confirmed by the authors with reference to the 9th edition of the INTERNATIONAL CLASSIFICATION OF DISEASES[13]. The injured areas of soft tissue included mucosa, skin, muscle, cartilage, facial nerve, and salivary gland. Bone-tissue injuries included mandibular (symphysis/parasymphysis, body, angle, and condyle) fracture, maxillary (Lefort I, II, and III types) fracture, and zygomatic arch fracture. The case distribution of soft-tissue injuries and facial fractures is shown in Table 1.

Table 1. Case distribution of 902 maxillofacial injuries

Injury types	Number of cases
Soft-tissue injuries	118 (13.1%)
Bone-tissue injuries	784 (86.9%)
Simple fractures	606 (67.2%)
Mandible	449 (49.8%)
Maxillary	54 (6.0%)
Zygomatic arch	103 (11.4%)
Compound fractures	178 (19.7%)
Multiple injuries	268 (29.8%)

Simple fracture: limited to isolated area (mandible, maxilla or zygomatic arch). Compound fracture: involving two or three anatomical areas. Multiple injuries: concomitant injuries in other parts of the body.

Maxillofacial Injury Severity Score method

The injury evaluation was limited to the maxillofacial region regardless of any other body injuries. The Maxillofacial Injury Severity Score (MFISS) method was designed to pick up the three highest Maxillofacial Injury Severity Scores according to the AIS-90 standard (Table 2), and then combine them with the injury severity scores for three maxillofacial functional parameters, malocclusion (MO), limited mouth opening (LMO), and facial deformity (FD) (Table 3). The MFISS could be calculated according to the following formula :

$$\mathrm{MFISS} = (A_1 + A_2 + A_3) \times (\mathrm{MO} + \mathrm{LMO} + \mathrm{FD})$$

where A_1, A_2, A_3 are the three highest maxillofacial AIS scores, and MO, LMO, FD are the maxillofacial functional parameter scores.

MO represents a possible outcome of dentition disarrangement resulting from fracture displacement and/or a segment defect. The malocclusion pattern (such as open bite, unilateral cross bite, excessive overjet, and so on) was difficult to assess by using scores, so the number of teeth and jaw involved was used instead. LMO indicates mandible motion disability resulting from bone, muscle, and joint injury, which could be assessed and given scores by measuring the interincisal opening distance. FD stands for facial disfigurement subsequent to fracture displacement, bone and/or soft-tissue defect, and other soft-tissue injury, which in the early stage of injury was frequently masked by swelling and hematoma. Therefore, assessment of facial disfigurement had to be made by a scaled description of anatomical injuries instead of facial deformity presentation.

Table 2. AIS-90 standard for facial injury scale (exclusion of eye and ear)

AIS-90	Description of injury
1	Contusion, lacerations, and avulsions $<25\ \mathrm{cm}^2$ of skin, subcutaneous and muscle (including lip, lid, auricle, and forehead)
	Rupture of external carotid arterial branches
	Superficial injuries of oral mucosa and tongue
	Ramus fracture, nasal fracture
	Teeth fracture, teeth displacement; teeth luxation
	Temporomandibular joint contusion
2	Lacerations >10 cm and avulsions $>25\ \mathrm{m}^2$ of skin, subcutaneous and muscle (including lip, lid, auricle, and forehead)
	Deeper and extensive tongue laceration
	Alveolar fracture, condylar fracture, mandibular body fracture
	Maxillary fracture (LeFort I, II)
	Open, displaced, comminuted nasal fracture
	Close orbital fracture
	Temporomandibular joint luxation
	Zygomatic fracture
	Facial nerve injury
3	Maxillary LeFort III fracture with loss of $<20\%$ blood
	Open, displaced, comminuted orbital fracture
4	Maxillary fracture with loss of $>20\%$ blood

Table 3. Maxillofacial functional injury scale

Index	Scores	Description of injury
LMO	1	Mouth opening range 2–3.7 cm
	2	Mouth opening range <2 cm
MO	1	Malocclusion of <6 teeth in single jaw
	2	Malocclusion of >6 teeth in single jaw
	3	Malocclusion in both jaws
FD	1	Open soft-tissue injury (<4 cm in length) without tissue defect Fracture without displacement
	2	Open soft-tissue injury (>4 cm in length), tissue defect <2 cm^2 Facial nerve branch injury Fracture with displacement, fracture with bone defect < half side of single jaw
	3	Open soft-tissue injury (>4 cm in length) and tissue defect >2 cm^2 Facial nerve trunk injury Bone defect > half side of single jaw, bone defect in both jaws

LMO: limited mouth opening; MO: malocclusion; FD: facial deformity.
Facial deformity scale was according to injury judgment standards of Chinese law and rules for Road Traffic Accidents.

Table 4a. MFISS of bone and soft-tissue injuries

Injured tissue	Number of patients	Score range	Mean score
Bone tissue	784	2–56	18.7
Soft tissue	118	1–20	6.5

$t = 1.96$, $P < 0.01$. MFISS: Maxillofacial Injury Severity Score.

Table 4b. MFISS of the various fracture groups

Fracture groups	Number of patients	Score range	Mean score
Simple mandibular fractures	449	1–42	19.3
Simple maxillary fractures	54	2–36	16.1
Simple zygomatic arch fractures	103	4–30	10.5
Compound fractures	178	6–56	25.6

$F = 84.95$, $P < 0.01$. MFISS: Maxillofacial Injury Severity Score.

MFISS calculation for clinical subjects

The 902 case documents were numbered from 1 to 902, and the distinguishable personal records such as name, sex, treatment date, and hospital title were deleted. Three senior registrars (the authors), trained in advance in use of the injury severity scale, were appointed to assess injury severity and give scores according to the descriptions of injury severity and scoring criteria shown in Tables 2 and 3. Each injury diagnosis was scored three times separately by the three senior registrars, and the final score for diagnosis was the mean of the three scores. The three highest maxillofacial AIS scores (A_1, A_2, A_3) and three maxillofacial functional parameter scores (MO, LMO, FD) were combined to calculate the MFISS for each patient.

Identification of bone-injury severity depended on review of computed tomography and/or X-ray images. Identification of the severity of soft-tissue injury was based on the records of physical examination. In judging malocclusion for the cases without a record of the number of involved teeth but with a description of malocclusion patterns, the score for the MO parameter was 1 for non- or slightly displaced fractures, 2 for seriously displaced fractures in a single jaw, and 3 for seriously displaced fractures in both jaws.

Statistical analysis

The MFISS for the various maxillofacial injuries was statistically analyzed to confirm the sensitivity of the proposed new scoring system in reflecting differences in maxillofacial injury severity.

Hospitalization days were used as a dependent variable. MFISS, type of treatment hospital, and associated injuries were independent variables. Correlation analysis was performed to screen out factors that significantly influence hospitalization days.

Treatment cost was used as another dependent variable. MFISS, days in hospital, whether operated on or not, type of treatment hospital, and associated injuries were independent variables. Correlation analysis was performed to screen out factors that significantly influence the cost of treatment.

All of the patients, divided into four groups based on the MFISS grades, days in hospital, and treatment cost, were statistically analyzed using one-way ANOVA.

Results

The MFISS for various maxillofacial injuries

The minimum injury severity score was 1 and the maximum score was 56 for the maxillofacial injuries involved in this study. The average score was 19.3 for simple mandibular fracture, 16.1 for simple maxillary fracture, and 10.5 for simple zygomatic arch fracture. The average score was 25.6 for compound fracture and 6.5 for soft-tissue injuries.

The comparison of MFISS between bone and soft-tissue injuries in the oral and maxillofacial region (Table 4a) showed a significant statistical difference ($P < 0.01$). The comparison of MFISS among various fracture groups in the oral and maxillofacial region (Table 4b) also showed a significant difference ($P < 0.01$).

The relationship between MFISS, days of stay in hospital, and medical resources consumption

Arranged by degree of influence on the number of days of stay in hospital, the factors were: MFISS, treated in specialized hospital or not, and associated injuries (Table 5). A positive correlation ($P < 0.01$) was seen between them. Arranged by degree of influence on expenses in hospital, the factors were: days in hospital, MFISS, operated on or not, treated in specialized hospital or not, and associated injuries (Table 6), and there was a positive correlation between them ($P < 0.01$).

Among four graded MFISS groups, the hospitalization days, and the treatment cost were compared. A significant difference ($P < 0.01$) was shown among them (Table 7; Figs 1 and 2).

Table 5. Multiple factor correlation analysis for days in hospital

Independent variables	Correlation coefficient
MFISS	0.226
Treating hospital	−0.212
Associated injury	0.177

$P < 0.01$. MFISS: Maxillofacial Injury Severity Score.

Table 6. Multiple factor correlation analysis for treatment cost

Independent variables	Correlation coefficient
Days in hospital	0.288
MFISS	0.263
Operation or not	0.235
Treating hospital	0.221
Associated injury	0.135

$P < 0.01$. MFISS: Maxillofacial Injury Severity Score.

Discussion

The use of trauma score and severity grade in trauma studies can provide the basis for deciding treatment strategy, guiding anesthetization and surgery, and predicting the survival probability of the injured patients and impact on health status in the future. The final results of such scores can offer better judgment of the condition of the injury, treatment assessment, and prediction of the prognosis in terms of epidemiology.

AIS and ISS are the most commonly used trauma scoring methods in current practice. A deficiency that these and their derivatives have in common is that the indices are insufficient in characterizing peculiarities of maxillofacial injury severity, so the results are often insensitive. For instance, zygomatic fractures that vary in injury severity from greenstick to extreme displacement, and further to comminution, have the same score grade in the AIS-90 scoring system. Similarly, in assessing maxillary and mandibular fractures, fracture displacement and its influence on consequent functional disability are ignored. In several studies on multiple traumas, the mean ISS was generally 16 or higher for the survivors[18] and more than 22–29 when the survival rate dropped down to 67–75%[21,22], whereas, in another study on multiple trauma involving maxillofacial regions, the facial AIS contribution to ISS was validated to be a poor indicator, the face AIS only scoring 1.4 versus the mean ISS of 24 in 254 cases[23], and 4 versus the mean ISS of 22 in 38/169 (22.4%) cases with facial trauma[5,6]. The AIS data worked out by Major et al.[15] was below 1.46 in assessment of injury severity in 172 cases of maxillofacial trauma admitted to a level I trauma center. It was suggested that the facial injury assessment method should be refined[6].

ISS allows just one injury per body region to be scored, which affected sensitivity in assessing maxillofacial injury severity. Although ISS was modified (NISS[17]) to become the sum of the squares of the AIS scores of each patients' three most severe injuries regardless of body region, it still appeared sluggish in evaluating the severity of maxillofacial multiple injuries for lower score indices. Some authors[14] have made attempts to revise the trauma severity score by raising the score value and/or increasing the parameter index of local, anatomical injured sites, but the factor of functional impairment has been neglected.

Table 7. Comparison of hospitalized days and treatment cost

MFISS score	Number of patients	Hospitalized days	Treatment cost (¥)
1–10	305	13.2	4,715
11–20	309	17.1	5,753
21–30	193	20.2	7,504
>31	99	22.3	10,071

$F = 22.3$, $P < 0.01$; $F = 43.5$, $P < 0.01$. MFISS: Maxillofacial Injury Severity Score; ¥: RMB Yuan.

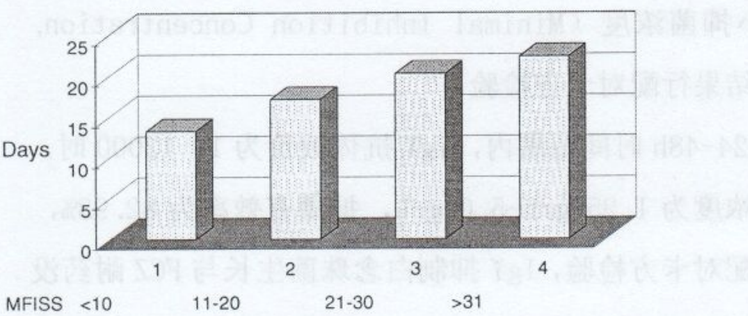

Fig. 1. Comparison of hospitalized days among the graded MFISS groups ($P < 0.01$).

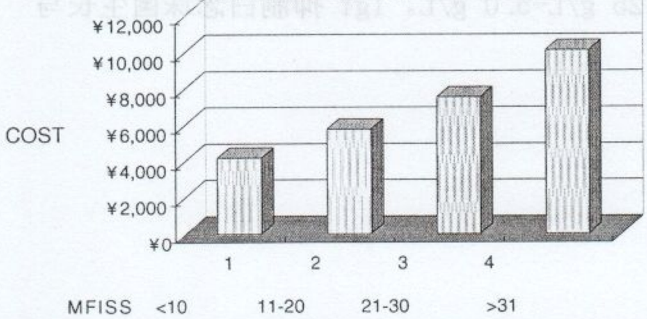

Fig. 2. Comparison of treatment cost among the graded MFISS groups ($P < 0.01$).

Maxillofacial trauma is characterized by injuries of differing severity, most of which are not life threatening. The main disabilities following maxillofacial trauma concern chewing, contour, and speech, and social/psychological obstacles. It has been well documented in the study by Girotto et al.[10] that complex facial fractures result in long-term physical impairment and functional outcomes such as diplopia, facial numbness, difficulty with eating and pain, with a large percentage of injury-related disability preventing employment. These prognostic consequences were impossible to predict using AIS or ISS methods. Therefore, the increase in the functional impairment index that predicts the influence of injury severity on life quality seems to be of importance in modifying or renewing the trauma scoring system. Furthermore, treatment planning for maxillofacial injuries, as opposed to body injury, is not completely determined by anatomic injury severity, but to a great extent depends on the degree of impairment of function and facial disfigurement. Malocclusion, limited mouth opening and facial deformity sometimes exert the most influence on the treatment of injuries in the maxillofacial region.

The MFISS was designed based on the above considerations. The scores of the three most severe injuries come from the maxillofacial region. This obviates the shielding of body-injury severity and exposes the peculiarity of maxillofacial anatomical injury severity. Three functional impairment indices are combined that are supposed to be helpful in determining treatment planning, inferring therapeutic medical resource consumption, and more accurately estimating the patient's prognosis.

In this study, it was demonstrated that the mean MFISS value was 19.3 for simple mandibular fractures, 16.1 for simple maxillary fractures, 10.5 for simple zygomatic arch fractures, 25.6 for compound fractures, and 6.5 for injuries of soft tissue. There was a significant difference in injury severity amongst groups, which indicated that the MFISS had a higher sensitivity in evaluating maxillofacial trauma. It has been noted that mandibular fracture scored a higher value in MFISS evaluation than maxillary or zygomatic arch fracture, which was in agreement with other studies[1,12,19,20,23]. In view of the outcome of functional recovery or disability, the result obtained from MFISS evaluation seemed logical. The higher ISS value for midfacial fractures presented in the literature can be attributed more to concomitant eye and/or head injury, such as traumatic blindness, subdural hematoma, and cerebral hematoma, which usually had a higher injury severity score[17,24,25].

To predict the consumption of medical resources and the length of hospital stay is one of the functions of a trauma scoring system. A retrospective study by Gray et al.[11] reported that ISS and a number of complications, including infections, and respiratory and hematologic complications, were the strongest predictors of length of hospital stay. The present study also showed a high significant correlation between MFISS and hospital stay days and medical resources consumption; therefore, MFISS can be presumed to be sensitive enough to predict the maxillofacial trauma patient's treatment cost and number of in-hospital days.

In this study, a total of 10 hospitals contributed patients. There was a covariant imbalance between treating hospital and initial observation of different types of injuries and severity. In order to reduce its interference with the veracity of the collected data as much as possible, the treating hospital candidates were controlled to be province-class or more highly ranked with an independent maxillofacial ward, and the registered cases were limited to those fulfilling the regulated criteria. Even so, some deviation of the data remained.

The MFISS proposed in this study still has limitations. In the make up of the MFISS, half of the indices are implanted from the AIS system. The deficiency AIS has in categorizing the consequences of maxillofacial trauma was thus inherited by the MFISS evaluation system, in that it does not adequately capture more severely displaced or comminuted maxillary fractures, ignores an array of nasoethmoidal and orbital fractures in combination with maxillary injury, and so on. A most significant modification in MFISS, different from any other scoring model, is that three functional impairment parameters are combined to characterize the peculiarities of maxillofacial injury. Rational determination of score grades for each parameter, and inclusion of malocclusion patterns and malocclusion in edentulous or partially edentulous segments, as well as pre-existing malocclusion, the reliable and valid scale for some functional impairments (such as those resulting from facial nerve injury), are issues that remained unsolved.

In all, this study has conceptualized a maxillofacial injury severity score, and preliminarily concludes that the proposed MFISS could reflect maxillofacial injury severity, to some extent, and be employed to estimate the consumption of medical resources and predict treatment result. It is believed that following further modification and improvement MFISS may become the rudiment of a widely accepted maxillofacial injury severity scoring system. It not only can be used to judge injury condition, assess treatment and predict prognosis, but can also aid the epidemiological and clinical study of maxillofacial trauma, with horizontally comparable data collected from different authors or units adopting the uniform injury severity scoring standard.

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Address:
Yi Zhang
Department of Oral and Maxillofacial Surgery
Peking University School of Stomatology
22# South Avenue
Zhong Guan Cun
Hai Dian District
Beijing 100081
PR China
Tel: +86 10 62179977x2295
Fax: +86 10 62173402
E-mail: zhangyi2000@263.net