UNIVERSIDADE FEDERAL DE MINAS GERAIS
PROGRAMA DE PÓS GRADUAÇÃO *LATO SENSU*
NEUROCIÊNCIAS E SUAS FRONTEIRAS

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MAXILLOFACIAL INJURIES ASSOCIATED WITH TRAUMATIC BRAIN INJURY: A SYSTEMATIC REVIEW

Belo Horizonte – MG, Brazil
2018

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Monography to the post-graduation program *lato sensu* Neurosciences and Its Frontiers of the Federal University of Minas Gerais, as part of the specialization course in Neurosciences.

Advisor: PhD. Aline Silva de Miranda

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2018

043 Alves, Paula Juliene Teles.
Maxillofacial injuries associated with Traumatic brain injury: a systematic review [manuscrito] / Paula Juliene Teles Alves. – 2018.

48 f. : il. ; 29,5 cm.

Orientadora: PhD. Aline Silva de Miranda.
Monography to the post-graduation program lato sensu Neurosciences and Its Frontiers of the Federal University of Minas Gerais, as part of the specialization course in Neurosciences.

1. Neurociências. 2. Traumatismos Craniocerebrais. 3. Traumatismos Maxilofaciais. I. Miranda, Aline Silva de. II. Universidade Federal de Minas Gerais. Instituto de Ciências Biológicas. III. Título.

CDU: 612.8

Ficha catalográfica elaborada pela Biblioteca do Instituto de Ciências Biológicas

Para minha amada família: Helias, Ivis, Pedro e Vera.

Agradeço a Deus pelo esforço recompensado; à minha família pelo imenso apoio; à minha orientadora Aline, pela paciência e confiança; Obrigada, Carol, pela amizade e constante ajuda e a todos que indiretamente contribuíram para a conclusão deste trabalho.

"The good surgeon knows how to operate;

A better surgeon knows when to operate;

The best surgeon knows when not to operate "

LIST OF TABLES AND ILLUSTRATIONS

LIST OF ACRONYMS AND ABBREVIATIONS

TBI: Traumatic Brain Injury

MFF: Maxillofacial Fractures

MFI: Maxillofacial Injury

MFT: Maxillofacial Trauma

PRISMA: Main Items to Report Systematic reviews and Meta-analyzes

pTBI : penetrating Traumatic Brain Injury

cTBI: closed Traumatic Brain Injury

MACE: Military Acute Concussion Evaluation

ISS: Injury Severity Score

GCS: Glasgow Coma Scale

CT: Computed tomography

CSF: Cerebrospinal fluid

ABSTRACT

The high rate of morbidity and mortality due to traumatic brain injury (TBI) is a major public health problem, since the treatment and follow-up of the affected patients have a significant social and economic impact. The bone complexity of the face and maxillofacial injury (MFI) that may sometimes be associated with TBI necessitates the present review that systematically discusses the evidence available in the literature associated with the potential relationships between the TBI and the MFI and its implications diagnostic and therapeutic. The research based on the PRISMA guideline was carried out by two researchers (Alves, PJT, Machado, CA) in the PubMed and Scopus databases, which presented a total of 27 competent articles to the topic of the 149 researched ones. Of this selection, 13 are retrospective studies, 9 prospective studies and 5 are cohorts. The preliminary result is a flowchart based on the PRISMA protocol detailing the search and inclusion and exclusion of articles. It is important to train all the emergency room professionals for the recognition of TBI and adequate initial management of the patients. The use of several TBI classifications makes it difficult to associate with MFIs. Further studies are needed to highlight the relationship between TBI and MFI and to stress the importance of concomitant management of both lesions and multidisciplinary conduction in the hospital settingfor in a better prognosis.

KEYWORDS: TRAUMATIC BRAIN INJURY; MAXILLOFACIAL INJURIES; HEAD INJURIES.

SUMMARY

1 INTRODUCTION

Traumatic Brain Injury (TBI) is an injury caused by external mechanical forces that can lead to anatomical and functional dysfunctions of both the skull and the brain. (MAGALHÃES *et al*, 2018). TBI lesions may arise in the direct impact area and elsewhere in the brain (PEIXOTO *et al*, 2015). Cranial lesions may promote lacerations, abrasions, avulsions, contusions, fractures, intracranial bleeding in addition to hypoxia and cerebral ischemia (MILORO *et al,* 2004). The high rate of morbidity and mortality due to TBI is a major public health problem, since the treatment and follow-up of the affected patients have a significant social and economic impact (OLIVEIRA *et al*, 2010).

Given the bone diversity of the viscerocranium, there are several types of classification for maxillofacial fractures (MFF) that can be associated with TBI. Maxillofacial Injury (MFI) may, for example, cause bleeding and secretions, such as cerebrospinal fluid; obturation of the pharynx by loosening of the base of the tongue, obstruction airways by fracture of the midface or by avulsion of teeth or dental prosthesis, factors incompatible with life if not treated in time (MILORO *et al*., 2004).

It is a routine of large emergency departments to evaluate and manage trauma-related facial injuries (DAVIDOFF *et al*., 1988). The early recognition of TBI and concomitant lesions in the initial assessment and in the treatment of patients for the reduction of morbidity and mortality is a priority (SCHEYERER *et al*, 2015). Understanding the source of the lesion and / or mechanism, severity level and dimension of facial trauma and concomitant lesions aid in the optimization of initial clinical treatment and correct definition of the time to involve the oral surgeon. (SCHEYERER *et al*, 2015).

The oral and maxillofacial surgeon should be aware of the occurrence of concomitant brain injury and have an understanding of the pathophysiology of TBI at initial recognition and treatment. Whatever patient is affected by maxillofacial injury, with or without associated fractures, he will be at risk of traumatic brain injury (CHOONTHAR *et al*, 2016). Thus, all patients with maxillofacial lesions should be under neurosurgical observation and continuous follow-up (RAJANDRAM *et al,* 2013).

The relationship between MFI due to TBI is limited in the literature considering thecomplex multidisciplinary nature, its high rates of morbidity and mortality and the need for joint scientific knowledge of the specialties in recognition, early diagnosis and rigorous cases of TBI. With the current debate about the exact definition of complications and their categorization (SALENTIJN *et al*, 2014), this study intends to make a systematic review in order to discuss the available evidence associated with the potential relationships between TBI and MFI and implications.

The medical and dental specialties should have joint access to the maximum of parameters in the diagnosis of TBI for the broadest benefit of the patients. Early intervention and rapid diagnosis is essential in the prevention of morbidity and mortality, especially with regard to the prevention of TBI, in the short-term duration of hypoxia and edema that may progress to permanent neurological and psychiatric deficits (RAJANDRAM *et al*, 2013).

This systematic review aims to dicuss emerging evidence regarding the impact of facial lesions resulting from TBI and to provide information that may contribute to clinical decision making, as well as to alert the multidisciplinary approach of polytrauma patients.

2 OBJECTIVES

The present review aims to discuss emerging evidence on the relationship between each type of TBI and MFI, as well as its diagnostic and therapeutic implications.

3 METHODS

3.1 Design

This systematic review was conducted according to the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta Analyses (PRISMA) (Moher *et al*, 2009).

3.2 Inclusion criteria

Observational studies as well as cross-sectional and cohort studies, all in the English language, were eligible for inclusion. Studies excluded from this review included: non-English articles, case reports, reviews, pediatric studies, laboratory / experimental / animal studies, sports, pathological lesions of non-traumatic origin and articles dealing with brain trauma and individual maxillofacial lesions.

3.3 Search methods for identification of studies

An electronic search for relevant articles was performed independently by two authors (Alves, P.J.T.; Machado, C.A.) using PUBMED and SCOPUS without period limitation. The search terms were TBI, MFI, head injuries, only in English language. The search combination used was: “TRAUMATIC BRAIN INJURY” **AND** “MAXILLOFACIAL INJURIES” **AND** “HEAD INJURIES”.

3.4 Selection of studies

Two researchers independently (Alves,P.J.T.; Machado, C.A.) reviewed the eligibility of the studies and analyzed their characteristics, quality, and accuracy. Studies were initially extracted for abstract screening and those found to be relevant were fully retrieved for a detailed review. Disagreements on eligibility were resolved by discussion between authors. Once the eligible studies were established, data were extracted by authors.

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4 RESULTS

A total of 149 articles were retrieved from our search. Initial screening to remove duplicates and studies with no apparent relevance yielded 100 unique articles. After excluding non-English articles, case reports, reviews, pediatric studies, laboratory / experimental / animal studies, sports, pathological lesions of non-traumatic origin and articles dealing with brain trauma and individual maxillofacial lesions, 27 studies were found to be relevant to assess the association of MFI associated with TBI. (Fig1).

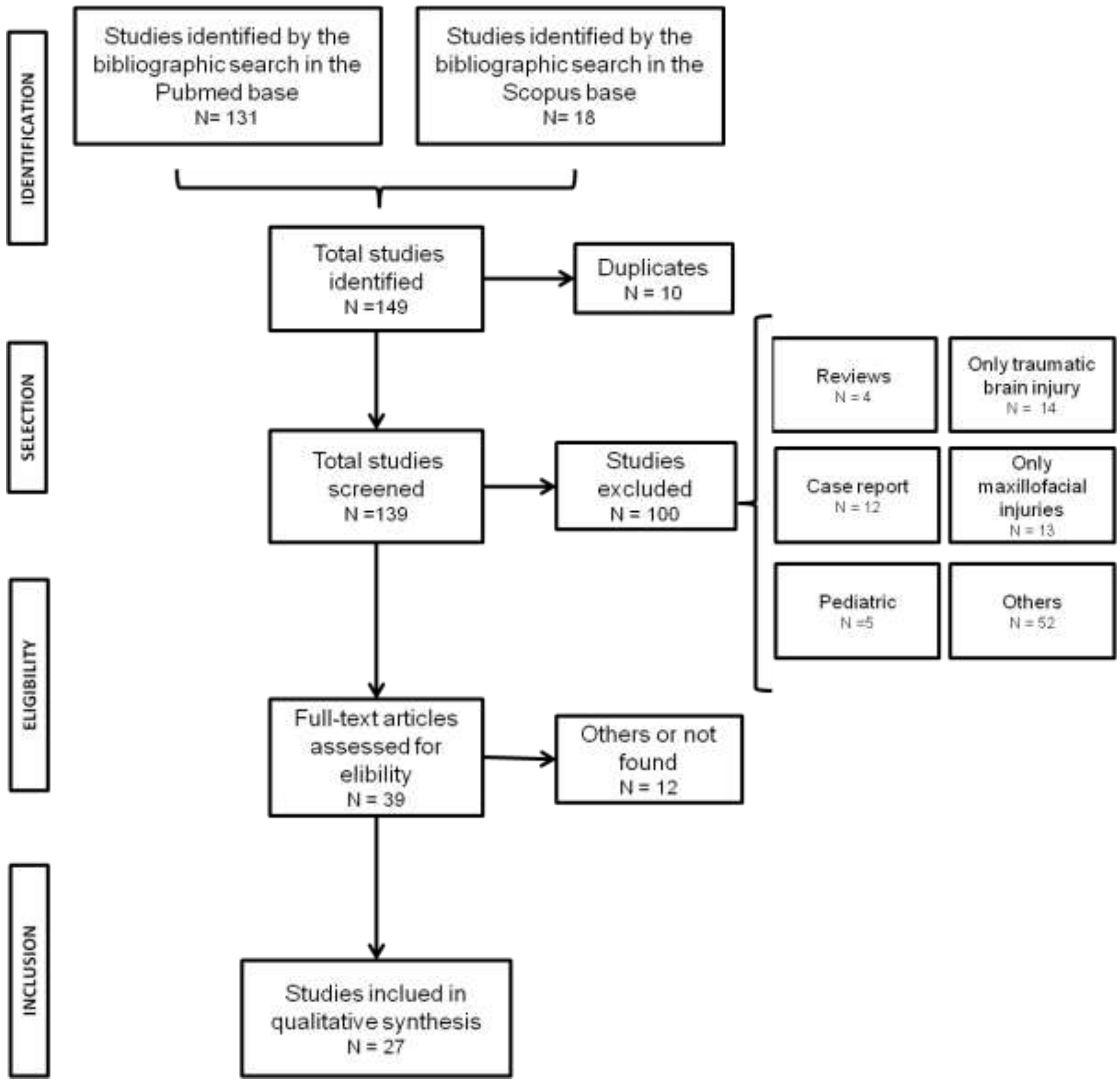

Fig. 1: PRISMA flow diagram for observational studies of correlation between the MFI associated with TBI.

4.1 Study characteristics

The selected studies (n = 27) investigated in this systematic review was 13 retrospective studies, 9 prospective studies and 5 cohorts, that presenting had very diverse populations with different age groups (from 1 to 93 years) and with a data from a period of 24 hours to 10 years.

4.2 TBI classification

It is generally known in the literature that the classification of TBI, produced by the Glasgow coma scale (GCS), is mild, moderate and severe. Of the articles, 8 mention this classification (RAJANDRAM *et al*, 2013; PULJULA *et al*, 2012; SALENTIJN *et al*, 2014; CAVALCANTE *et al* ,2012; HUANG *et al* 2012; CZERWINSKI *et al*, 2008; RAZAK *et al,* 2017; HAMMOND *et al*, 2018). Another 9 articles use other minor and major brain injuries, penetrating TBI (pTBI) and closed TBI (cTBI), concussion, concussion with or without less consciousness, mild/moderate/severe head injuries, anterior/middle/posterior fossa injuries(GRANT *et al*, 2012; FARES *et al*, 2014; PAPPACHAN *et al*, 2006; HOLMGREN *et al,* 2004; WANYURA *et al,* 2014; ALADELUSI *et al*, 2014; SOBIN *et al*, 2016; GÖNÜL *et al,* 2005; HAMMOND *et al,* 2018). 12 articles showed only the characteristics of the TBI as concussion, skill fractures, hemorrage, haematoma, edema, diffuse injuries, focal injuries, contusion, amnesia, loss of consciousness, skin laceration, cerebral edema, pneumocephalus, neurologic injuries, ophthalmologic injuries and pneumocranium (VEERAMUTHU *et al*, 2016; ŽIVKOVIĆ *et al*, 2014; CHU *et al*, 2011; PAPPACHAN *et al*, 2006; COSSMAN *et al*, 2014; SCHEYERER *et al*, 2015; LOPES ALBUQUERQUE *et al*, 2014; HUANG *et al*, 2017; STEPHENS *et al*, 2016; HOLMGREN *et al*, 2004; WANYURA *et al*, 2014; CAI *ET AL*, 2017), 3 articles shows the types and features (RAJANDRAM *et al*, 2013; CZERWINSKI *et al,* 2008; ALADELUSI *et al*, 2014), while 3 articles did not present any characteristics or evidenced some type of TBI (ŽIVKOVIĆ *et al*, 2014; KRAUS *et al*, 2003; CHU *et al*, 2011).

4.3 Causes of TBI and MFI

The most common causes of these lesions were, respectively, road traffic accidents (RAJANDRAM *et al*,2013; GRANT *et al*, 2012; PULJULA *et al*, 2012; SALENTIJN *et al*, 2014; CAVALCANTE *et al*, 2012, KRAUS *et al*, 2003; PAPPACHAN *et al*, 2006; COSSMAN *et al*, 2014; SCHEYERER *et al*, 2015; HUANG *et al*, 2017; CZERWINSKI *et al*, 2008; STEPHENS *et al,* 2016; WANYURA *et al*, 2014; SOBIN *et al*, 2016; RAZAK *et al,* 2017; CAI *et al*, 2017; VEERAMUTHU *et al*, 2016; LOPES ALBUQUERQUE *et al,* 2014; HOLMGREN *et al,* 2004), falls (RAJANDRAM *et al*, 2013; GRANT *et al*, 2012; SALENTIJN *et al*, 2014; CAVALCANTE *et al*, 2012; KRAUS *et al,* 2003; COSSMAN *et al*, 2014; SCHEYERER *et al*, 2015; HUANG *et al*, 2017; LOPES ALBUQUERQUE *et al*, 2014; HOLMGREN *et al,* 2004; ŽIVKOVIĆ *et al*, 2014), and Assault (RAJANDRAM *et al,* 2013; GRANT *et al,* 2012; SALENTIJN *et al*, 2014; SCHEYERER *et al*, 2015; SOBIN *et al*, 2016; CAI *et al,* 2017). Other causes associated with TBI were Sport injury (RAJANDRAM *et al*, 2013; GRANT *et al*, 2012; PULJULA *et al*, 2012; SOBIN *et al*, 2016; RAZAK *et al*, 2017), Industrial injury (RAJANDRAM *et al*, 2013; RAZAK *et al,* 2017), Gunshot (KELLER *et al*, 2015; CZERWINSKI *et al,* 2008), Munitions (FARES *et al*, 2014; GÖNÜL *et al*, 2005), Handmine and Blast (KELLER *et al*, 2015), Earthquake (CHU *et al,* 2011).

4.4 TBI Features

The most cited TBI features were skull fractures (KRAUS *et al*, 2003; CHU *et al*, 2011; PAPPACHAN *et al*, 2006; COSSMAN *et al*, 2014; HUANG *et al*, 2017; STEPHENS *et al*, 2016; ALADELUSI *et al*, 2014; GÖNÜL *et al*, 2005; CAI *et al*, 2017), Hemorrhage (RAJANDRAM *et al*, 2013; CHU *et al*, 2011; PAPPACHAN *et al*, 2006; SCHEYERER *et al*, 2015; HUANG *et al*, 2017; CZERWINSKI *et al*, 2008; CAI *et al*, 2017), Hematoma (ŽIVKOVIĆ *et al*, 2014; CHU *et al*, 2011; HUANG *et al,* 2017; CZERWINSKI *et al*, 2008; WANYURA *et al*, 2014; CAI *et al*, 2017) and concussion (RAJANDRAM *et al*, 2013; PAPPACHAN *et al*, 2006; HOLMGREN *et al*, 2004; WANYURA *et al*, 2014; SOBIN *et al*, 2016; HAMMOND *et al*, 2018). Other characteristics related to TBI were loss of consciousness (VEERAMUTHU *et al*, 2016; LOPES ALBUQUERQUE *et al*, 2014; HOLMGREN *et al*, 2004), Contusion (RAJANDRAM *et al*, 2013; PAPPACHAN *et al*, 2006; CAI *et al*, 2017), skin lacerations (FARES *et al*, 2014; PAPPACHAN *et al*, 2006), diffuse injuries (RAJANDRAM *et al*, 2013; CZERWINSKI *et al*, 2008), amnesia (VEERAMUTHU *et al,* 2016; LOPES ALBUQUERQUE *et al*, 2014), Edema (HUANG *et al*, 2017), focal injuries (Rajandram *et al*, 2013), neurologic injuries (Cossman *et al*, 2014; LOPES ALBUQUERQUE *et al*, 2014), ophtalmologic injuries (COSSMAN *et al*, 2014), Pneumocranium (WANYURA *et al*, 2014), cerebral edema, pneumocephalus and cephalophyma (CHU *et al*, 2011) and pTBI and cTBI (FARES *et al*, 2014).

4.5 MFI classification

Facial fractures are basically classified as Le Fort I, II and III or carry the name of the affected bone (OCHS *et al*, 2005). Of the 27 articles, 19 used the classification by name of fractured maxillofacial bones (RAJANDRAM *et al*, 2013; GRANT *et al*, 2012; KELLER *et al*, 2015; PULJULA *et al*, 2012; ŽIVKOVIĆ *et al*, 2014; KRAUS *et al*, 2003; CHU *et al*, 2011; HUANG *et al*, 2012; PAPPACHAN *et al*, 2006; COSSMAN *et al*, 2014; SCHEYERER *et al*, 2015; HUANG *et al,* 2017; CZERWINSKI *et al*,2008; STEPHENS *et al*, 2016; HOLMGREN *et al*, 2004; WANYURA *et al*, 2014; SOBIN *et al*, 2016; GÖNÜL *et al*, 2005; CAI, *et al,* 2017), 3 articles used the upper / middle / lower third face classification (RAJANDRAM *et al*, 2013; LOPES ALBUQUERQUE *et al*, 2014; HUANG *et al*, 2017), 2 articles presented the classification according to the affected facial bone and other facial lesions (LOPES ALBUQUERQUE *et al*, 2014; ALADELUSI *et al,* 2014) and 1 article did not mention any classification for facial injuries (HAMMOND *et al*, 2018). The Le Fort fracture, when mentioned in 4 articles, appears concomitantly with other lesion classifications (GRANT *et al*, 2012. PAPPACHAN *et al*, 2006; SCHEYERER *et al*, 2015; HOLMGREN *et al*, 2004). The other facial lesions mentioned were: Tissue or muscle and mixed injuries (VEERAMUTHU *et al*, 2016), nerve injury, visual deficiency, soft tissue damage (SALENTIJN *et al*,2014; FARES *et al*, 2014), occlusal disturbance, hemorrhage (SALENTIJN *et al*, 2014), lip injury, eyelid injury (CAVALCANTE *et al*, 2012), abrasion, contusion/haematoma and laceration (RAZAK *et al*, 2017) and tooth lesions (SCHEYERER *et al*, 2015).

4.6 MFI features

Of the 23 articles that associates facial fractures with TBI, 19 articles correlate multiple fractures (RAJANDRAM *et al*, 2013; GRANT *et al*, 2012; KELLER *et al*, 2015; VEERAMUTHU *et al*, 2016; PULJULA *et al*, 2012; SALENTIJN *et al*, 2014; KRAUS *et al*, 2003; CHU *et al*, 2011; PAPPACHAN *et al*, 2006; SCHEYERER *et al*, 2015; LOPES ALBUQUERQUE *et al*, 2014; HUANG *et al*, 2017; CZERWINSKI *et al*, 2008; STEPHENS *et al*, 2016; HOLMGREN *et al*, 2004; WANYURA *et al*, 2014; ALADELUSI *et al*, 2014; SOBIN *et al*, 2016; CAI. *et al*, 2017) and 4 articles reported incidence of isolated facial fractures (ŽIVKOVIĆ *et al*, 2014; HUANG *et al*, 2012; COSSMAN *et al*, 2014; GÖNÜL *et al*, 2005). Soft tissue injury were reported in 8 articles (VEERAMUTHU *et al*, 2016; SALENTIJN *et al*, 2014; CAVALCANTE *et al*, 2012; FARES *et al*, 2014; SCHEYERER *et al*, 2015; HUANG *et al*, 2017; ALADELUSI *et al*, 2014; RAZAK *et al*,2017).

4.7 MFI with TBI

Of the 27 studies selected, 9 articles reported that an association between the two lesions and stated that MFI increases the risk of TBI (RAJANDRAM *et al*, 2013; GRANT *et al*, 2012; KRAUS *et al*, 2003; CHU *et al*, 2011, PAPPACHAN *et al*, 2006; SCHEYERER *et al*, 2015; HUANG *et al*, 2017; CZERWINSKI *et al*, 2008; ALADELUSI *et al*, 2014). It was verified the relation of the TBI with: frontal sinus fracture (STEPHENS *et al*, 2016), orbital lesions (ŽIVKOVIĆ *et al*, 2014; HUANG *et al*, 2012; COSSMAN *et al*, 2014; HOLMGREN *et al*, 2004; GÖNÜL, *et al*, 2005), the midface fracture (HUANG *et al*, 2012; LOPES ALBUQUERQUE *et al*, 2014) and isolated fracture of the mandible (CZERWINSKI *et al*, 2008; SOBIN *et al*, 2016; HAMMOND *et al*, 2018). Also, three articles recommends the reduction of fractures to the cranium, thus preventing cerebral spinal fluid (CSF) overflow, meningitis and infections (KELLER *et al*, 2015; HOLMGREN *et al*, 2004; GÖNÜL *et al*, 2005). Five articles assert that mild TBI should be suspected in patients with facial injuries and lower face lacerations (GRANT *et al*, 2012; VEERAMUTHU *et al*, 2016; RAZAK *et al*, 2017; HAMMOND *et al*, 2018). In addition, there's a high suspicion for concussion when accompanied mild TBI associated with isolated mandibular fractures (SOBIN *et al*, 2016; HUANG *et al*, 2012). Two article reveals that the use of motorcycle helmet prevents the MF but not the TBI (LOPES ALBUQUERQUE *et al*, 2014; RAZAK *et al,* 2017). Seven articles recommend the use of skull and face CT (HUANG *et al*, 2012; SCHEYERER *et al*, 2015; HUANG *et al*, 2017; CZERWINSKI *et al*, 2008; HOLMGREN *et al*, 2004; GÖNÜL *et al*, 2005; HAMMOND *et al*, 2018), two of which advocate the use of CT for better investigation of orbital fractures (HOLMGREN *et al*, 2004; GÖNÜL *et al*, 2005). To aid the Glasgow Coma Scale(GCS), 2 articles made use of the scales: Military Acute Concussion Evaluation(MACE) (SOBIN *et al*, 2016) and Injury Severity Score (ISS) (HOLMGREN *et al*, 2004). Four articles advocate multidisciplinary treatment (PULJULA *et al*, 2012; COSSMAN *et al*, 2014; SCHEYERER *et al*, 2015; CHU *et al*, 2011).

4.8 TBI and MFI Management

Of the 27 articles, three approach the treatment and complications from TBI and MFI (SALENTIJN *et al*, 2014; CHU *et al*, 2011; COSSMAN *et al*, 2014). The most common complications are: Nerve injury iInfection/ inflammation, occlusal disturbance, visual deficiency, soft tissue damage, facial bone defect, psychiatric /

psychological disorder, neurological deficit, hemorrhage / blood loss and physiological dysregulation (SALENTIJN *et al*, 2014). Others complications found are upper respiratory tract obstruction, haematocele and parapharyngeal soft tissue swelling and pharyngeal stenosis (CHU *et al*, 2011). One study made a very interesting correlation. Severe TBI is mainly related with physiological dysregulation, infection/inflammation, psychiatric/psychologic disorders and neurological deficits. in the incidence of moderate TBI, it is more associated with facial fratures, nerve injuries and soft tissue damages while that not were observed, development of complications in mild TBI (SALENTIJN *et al*, 2014).

One article listed the 13 treatments used for complications of TBI and MFI. They are: conservative treatment, decompression, antibiotic treatment, secondary facial correction, foreign body removal, specialist consultation, pharmacological treatment (non-antibiotic), cooling / sedation, surgical intervention, compression, blood transfusion and ventilatory support. Of these, the most common treatment modality was pharmacological (non-antibiotic) treatment, followed by antibiotic treatment, conservative treatment, and decompression therapy in the cases of haematoma (SALENTIJN *et al*, 2014). Another article mentioned that the most applied treatments to the orbital roof fractures treatment is bone reduction, absorbable mesh, plate and split calvaria (COSSMAN *et al*, 2014). Soft tissue injury debridement with antibiotics and ocular enucleation are other modalities of the treatments found (CHU *et al*, 2011).

5 DISCUSSION

The TBI is an injury due to mechanical force against the brain leading to the anatomical and functional impairment of the soft parts, such as scalp and meninges and the brain itself, and hard tissues such as bones of the skull. This condition can lead to both transient and permanent neuropsychiatric changes (MACEDO *et al*, 2006).

One of the most accepted ways to classify TBI is to perform the GCS, which assesses the level of consciousness, aiding in therapeutic and diagnostic decision-making, sorting the TBI is mild, moderate or severe, and also evaluating the prognosis of TBI was mentioned in nineteen articles (RAJANDRAM *et al*, 2013; GRANT *et al*, 2012; VEERAMUTHU *et al,* 2016; PULJULA *et al*, 2012; SALENTIJN *et al*, 2014; CAVALCANTE *et al*, 2012; HUANG *et al*, 2012; PAPPACHAN *et al*, 2006; COSSMAN *et al*, 2014; SCHEYERER *et al*, 2015; HUANG *et al*, 2017; CZERWINSKI *et al*, 2008; STEPHENS *et al*, 2016; HOLMGREN *et al*, 2004; ALADELUSI *et al*, 2014; GÖNÜL *et al*, 2005; RAZAK *et al*, 2017; HAMMOND *et al*, 2018; CAI *et al*, 2017). Eight articles did not use the GCS given the goal of their studies, as autopsy study, maxillofacial studies, surgical study, motorcycle helmets and ammunition study (KELLER *et al*, 2015; ŽIVKOVIĆ *et al*,2014; KRAUS *et al* , 2003; CHU *et al*, 2011; FARES *et al*, 2014; LOPES ALBUQUERQUE *et al*, 2014; WANYURA *et al* , 2014; SOBIN *et al*, 2016). The ISS is an established medical score to assess trauma severity. It correlates with mortality, morbidity and hospitalization time after trauma, made by the Committee of the Association for the Advancement of Automotive Medicine that designed and promotes improvements in the scale (BAKER *et al*, 1974; COPES *et al*, 1988). The MACE is a medical screening and documentation measure that is used to gauge the severity of symptoms and cognitive deficits after a diagnosis of a concussion has been made. It has been distributed to US military and care for veterans and active-service members who have sustained a TBI (KENNEDY *et al*, 2013). The ISS and MACE accessory scales were used respectively in tomographic studies of the lesions and in the study of isolated jaw fractures associated with concussion (HOLMGREN *et al,* 2004; SOBIN *et al*, 2016). The use of classifications that do not contemplate the classic classification GCS (mild, moderate and severe), as seen in item 4.2, makes the correlation between MFI and its implications unfeasible.

The main causes of TBI are road traffic accidents, physical assault and falls, and most of them occurred in young adult males (ANDRADE *et al*, 2009; RAJANDRAM *et al*, 2013; GRANT *et al*, 2012; PULJULA *et al*, 2012; SALEJIN *et al*, 2014; CAVALCANTE *et al*, 2012; ŽIVKOVIĆ *et al*, 2014; KRAUS *et al*, 2003; PAPPACHAN *et al*, 2006; COSSMAN *et al*, 2014; SCHEYERER *et al*, 2015; LOPES ALBUQUERQUE *et al*, 2014; HUANG *et al*, 2017; CZERWINSKI *et al*, 2008; STEPHENS *et al*, 2016; HOLMGREN *et al*, 2004; ALADELUSI *et al*, 2014; RAZAK *et al*, 2017; CAI *et al*, 2017). Although the use of a helmet reduces the risk of MFF, it does not prevent TBI. Therefore the most serious accidents occur on a motorcycle (KRAUS *et al*, 2003; LOPES ALBUQUERQUE *et al*, 2014; CAVALCANTE *et al*, 2012). This finding is worrying because this patients can stare at long-time reabilitation and permanent neurological problems.

The facial region when traumatized usually presents soft tissue, teeth, jaw, maxilla, zygomatic, naso-orbito-etmoidal complex and periorbital and paranasal sinuses lesions. There are numerous nomenclatures for the classification of FBMF, such as Le Fort I, II, III; nasal, mandibular, naso-orbito-etmoidal fracture, roof and orbital blowout among others (OCHS *et al*, 2005).

The MFFs are usually associated with other lesions, such as soft tissue, eyeball, and encephalon (CARVALHO *et al*, 2010; VEERAMUTHU *et al*, 2016; SALENTIJN *et al*, 2014; SCHEYERER *et al*, 2015; HUANG *et al*, 2017; ALADELUSI *et al*, 2014). When considering the individual facial bones, the central midfacial bone is associated more commonly with TBI, be related the fragility of the region by accommodating the maxillary sinuses (PAPPACHAN *et al*, 2006). Although that almost 66,67% of the orbital roof fractures are associated with TBI, the orbital fractures are commonly overlooked (HOLMGREN *et al*, 2004; CZERWINSKI *et al,* 2008). It requires a secondary scan for accurate diagnosis, not being diagnosed by the cranial CT and demanding the use of facial CT, considered adequate for the accurate diagnosis for the diagnosis of these fractures. (COSSMAN *et al*, 2014; HUANG *et al*, 2017; HOLMGREN *et al,* 2004; CZERWINSKI *et al*, 2008; SCHEYERER *et al*, 2015; GÖNÜL *et al*, 2005).

The association between MFI increases the risk of TBI is due to the fact that facial bones, which, in addition to storing the eyeballs, primordial to the eyesight are part of the upper airways which, when obstructed by fractures, edema, hemorrhage or CSF, are a risk for the maintenance of life when not treated (RAJANDRAM *et al*, 2013; GRANT *et al*, 2012; KRAUS *et al*, 2003; CHU *et al*, 2011; PAPPACHAN *et al,* 2006; SCHEYERER *et al*, 2015; HUANG *et al*, 2017; CZERWINSKI *et al*, 2008; ALADELUSI *et al*, 2014).

The articles did not always discriminate each type of TBI and correlated its relation with the MFI, a factor that signals the need for further investigation. When reported, the mild, moderate and severe TBI were interesting: The severe TBI was correlated in coma patients with secondary bone healing in mandibular condyle and mandibular fractures (HUANG *et al*, 2012). Some hypotheses were drawn and the most relevant is the possibility of a proliferation of humoral factors osteogenic due to damage of the blood-brain barrier. The moderate TBI was related to most motorcycle accidents (CAVALCANTE *et al,* 2012), given that the prevalence group is young men, and the treatment and rehabilitation of these patients is usually prolonged and strenuous. The mild TBI that frequently remains unrecorded in subjects with MFI (GRANT *et al*, 2012; PULJULA *et al,* 2012), was related to the higher severity of MFI, facial contusion, haematoma and inferior facial laceration, and midface fractures.(RAZAK *et al*, 2017). Another aspect of the mild TBI is that the affected patients appear to treat MFI with maxillofacial surgeons and are often not referred for TBI investigation (HAMMOND *et al,* 2018). This fact raises the importance of knowledge and preparedness to suspect potential incidence of TBI and MFI.

It is of utmost importance that multi-disciplinary patient care should be effectively collaborated for the survival and better functional recovery of the victim. (CARVALHO *et al*, 2010; GÖNÜL *et al*, 2005). Ideally, every pacient with craniofacial fracture should be examined by a neurologist or a neurosurgeon, but this is not always possible. Four articles report the importance of multidisciplinary management that is strongly important for the treatment and rehabilitation of the patients (PULJULA *et al*, 2012; COSSMAN *et al*, 2014; SCHEYERER *et al*, 2015). Therefore, regular updating seminars of signs and symptoms of TBI should be mandatory for all emergency room personnel (PULJULA *et al*, 2012).

The best treatment of maxillofacial lesions may be compromised in some cases, when deference for neurosurgical concerns is required (SALENTIJN *et al*, 2014; SCHEYERER *et al*, 2015). MFI are often associated with a risk of other serious concomitant injuries, the TBI, particularly. Even though emergency operations are only necessary in rare cases, diagnosis and treatment of such concomitant injuries have the potential to be overlooked or delayed in severely injured patients. A variety of complications frequently arise which often necessitate further treatment and prolonged hospitalisation (SALENTIJN *et al*, 2014; SCHEYERER *et al,* 2015)

Both diagnoses for TBI and MFI are performed clinically and by imaging. Imaging research for CT is widely advocated for both cranial and MFF, especially orbital fractures and the anterior skull base (RAJANDRAM *et al*, 2013; HUANG *et al*, 2017; CZERWINSKI *et al*, 2008; HOLMGREN *et al*, 2004). The presence of MFI worsens the prognosis of TBI (RAZAK *et al*, 2017) because the facial skeleton can transmit forces directly to the neurocranium, resulting in severe brain injury (ALADEUSI *et al*, 2014). On the other hand, other authors argue that facial fractures present a low risk of traumatic brain injury, since they affirm that the bones of the face act as brain protectors when crushed in an episode of trauma, a phenomenon known as the Crumple Zone (PAPPACHAN *et al*, 2006; CAI *et al*, 2017).

Patient care with TBI and MF involves several steps that determine the success of the prognosis (CARVALHO *et al,* 2010; WANYURA *et al*, 2014). The direct relationship between the severity of maxillofacial injury and head, ophtalmologic injury and polytrauma, emphasizes the need for thorough examination of patients, especially in patients who suffered high impact trauma.(ALADELUSI *et al*, 2014)

The management of patients with TBI and MF is a major challenge with regard to optimal treatment. Care with these patients requires engaged multidisciplinary involvement and requires skills such as airway stabilization, expertise ilimited to performing tracheotomy, ability to facial fracture repair, tecidual repair, and control of epistaxis and infection control (KELLER *et al*, 2015).

7 FINAL CONSIDERATIONS

According to the literature found, the major causes of TBI is the road traffic accident, assault and falls, as described in the literature. Facial lesions that require surgical treatment are often neglected in detriment of neurological injuries or unawareness of their existence. Few studies directly correlate mild, moderate and severe TBI with MFI incidence. CT is considered adequate for the accurate diagnosis of TBI and MFI. An interesting question raised was the need to better prepare the multidisciplinary team in the care and conduct of trauma cases in a multidisciplinary way. The evidence on the relationship between each type of TBI and MFI, as well as its diagnostic and therapeutic implications are camouflaged by the lack of standardization in the description of TBI. More studies are needed to show the relationship between each type of TBI and MFI to proof the importance of concomitant and multidisciplinary management of both lesions for a better prognosis.

REFERENCES

ALADELUSI, T.; AKINMOLADUN, V.; OLUSANYA, A.; AKADIRI,O.; FASOLA,A**. Analysis of Road Traffic Crashes–Related Maxillofacial Injuries Severity and Concomitant Injuries in 201 Patients Seen at the UCH, Ibadan.** Craniomaxillofac Trauma Reconstruction. 2014. v.7. p.284–289. DOI http://dx.doi.org/10.1055/s-0034-1378183. ISSN 1943-3875.

ANDRADE, A.F.; PAIVA, W.S.; AMORIM, R.L.O.; FIGUEIREDO, E.G.; NETO, E.R.; TEIXEIRA, M.J. **Mecanismos de lesão cerebral no traumatismo cranioencefálico.** Rev Assoc Med Bras.2009. v.55(1). p.75-81. DOI: http://dx.doi.org/10.1590/S0104-42302009000100020

BAKER SP, O'Neill B, Haddon W, Long WB (1974). **The Injury Severity Score: a method for describing patients with multiple injuries and evaluating emergency care.** The Journal of Trauma. Lippincott Williams & Wilkins. 14 (3): 187–196. doi:10.1097/00005373-197403000-00001. PMID 4814394.

CAI SS, MOSSOP C, DIACONU SC, HERSH DS, ALFADIL S, RASKO YM, CHRISTY MR, GRANT MP, NAM AJ. **The "Crumple Zone" hypothesis: Association of frontal sinus volume and cerebral injury after craniofacial trauma.** J Craniomaxillofac Surg. 2017 Jul;45(7):1094-1098. doi: 10.1016/j.jcms.2017.04.005. Epub 2017 Apr 25. Erratum in: J Craniomaxillofac Surg. 2017 Nov;45(11):1907. PubMed PMID: 28551409.

CARVALHO, M.F.; HERRERO, R.K.R.; MOREIRA, D.R.; URBANO, E.S.; REHER, P**. Principles of Manegement of Hospitalized Patients in Oral and Maxilo Facial Surgery**. Rev. Cir. Traumatol. Buco-Maxilo-Facial., Camaragibe v.10, n.4, p. 79-84, out./dez.2010. ISSN 1808-5210 (versão online).

CAVALCANTE JR, OKA SC, DE SANTANA SANTOS T, DOURADO E, DE OLIVEIRA E SILVA ED, GOMES AC. **Influence of helmet use in facial trauma and moderate traumatic brain injury victims of motorcycle accidents.** J Craniofac Surg. 2012 Jul;23(4):982-5. doi: 10.1097/SCS.0b013e31824e5b04. PubMed PMID: 22777446.

CHOONTHAR, M.M.; RAGHOTHAMAN, A.; PRASAD, R.; PRADEEP, S.; PANDYA, K. Head Injury: **A maxillofacial surgeon's perspective**.Journal of Clinical and Diagnostic Research. 2016, Jan, Vol-10(1). DOI: 10.7860/JCDR/2016/16112.7122

CHU ZG, YANG ZG, DONG ZH, CHEN TW, ZHU ZY, DENG W, XIAO JH. **Features of cranio-maxillofacial trauma in the massive Sichuan earthquake: analysis of 221 cases with multi-detector row CT**. J Craniomaxillofac Surg. 2011 Oct;39(7):503-8. doi: 10.1016/j.jcms.2010.10.022. Epub 2010 Nov 26. PubMed PMID: 21112795.

COPES, W.S.; H.R. Champion; W.J. Sacco; M.M. Lawnick; S.L. Keast; L.W. Bain (1988). **The Injury Severity Score revisited**. The Journal of Trauma. Lippincott Williams & Wilkins. 28 (1): 69–77. doi:10.1097/00005373-198801000-00010. PMID 3123707.

COSSMAN JP, MORRISON CS, TAYLOR HO, SALTER AB, KLINGE PM, SULLIVAN SR. **Traumatic orbital roof fractures: interdisciplinary evaluation and management.** Plast Reconstr Surg. 2014 Mar;133(3):335e-343e. doi: 10.1097/01.prs.0000438051.36881.e0. PubMed PMID: 24572878.

CZERWINSKI M, PARKER WL, WILLIAMS HB. **Algorithm for head computed tomography imaging in patients with mandible fractures.** J Oral Maxillofac Surg. 2008 Oct;66(10):2093-7. doi: 10.1016/j.joms.2008.04.011. PubMed PMID: 18848107.

DAVIDOFF, G.; JAKUBOWSKI, M.; THOMAS, D.; ALPERT, M. **The spectrum of closed-head injuries in facial trauma victims: incidence and impact**. Ann Emerg Med. 1988. n.17, p.6-9. DOI: https://doi.org/10.1016/S0196-0644(88)80492-X

FARES Y, FARES J, GEBEILY S. **Head and facial injuries due to cluster munitions.** Neurol Sci. 2014 Jun;35(6):905-10. doi: 10.1007/s10072-013-1623-2. Epub 2014 Jan 4. PubMed PMID: 24389857.

GÖNÜL E, ERDOĞAN E, TAŞAR M, YETIŞER S, AKAY KM, DÜZ B, BEDÜK A, Timurkaynak E. **Penetrating orbitocranial gunshot injuries**. Surg Neurol. 2005 Jan;63(1):24-30; discussion 31. PubMed PMID: 15639513.

GRANT, A.L.; RANGER, A.; YOUNG, G.B.; YAZDANI,A. **Incidence of Major and Minor Brain Injuries in Facial Fractures.** The Journal of Craniofacial Surgery. 2012. v..23. n.5. p.1324-1328. DOI: 10.1097/SCS.0b013e31825e60ae.

HAMMOND D, WELBURY R, SAMMONS G, TOMAN E, HARLAND M, RICE S. **How do oral and maxillofacial surgeons manage concussion?** Br J Oral Maxillofac Surg. 2018 Feb;56(2):134-138. doi: 10.1016/j.bjoms.2017.12.014. Epub 2018 Jan 8. PubMed PMID: 29325790.

HOLMGREN EP, DIERKS EJ, HOMER LD, POTTER BE. **Facial computed tomography use in trauma patients who require a head computed tomogram**. J Oral Maxillofac Surg. 2004 Aug;62(8):913-8. PubMed PMID: 15278853.

HUANG LK, WANG HH, TU HF, FU CY. **Simultaneous head and facial computed tomography scans for assessing facial fractures in patients with traumatic braininjury Injury.** 2017 Jul;48(7):1417-1422. doi:10.1016/j.injury.2017.04.046. Epub 2017 Apr 24. PubMed PMID: 28455003.

HUANG W, Li Z, Li Z, YANG R**. Does traumatic brain injury result in accelerated mandibular fracture healing?** J Oral Maxillofac Surg. 2012 Sep;70(9):2135-42. doi:10.1016/j.joms.2012.04.016. PubMed PMID: 22907111.

KELLER, M.W.; HAN, P.P.; GALARNEAU, M.R.; GABALL, C.W. **Characteristics of Maxillofacial Injuries and Safety of In Theater Facial Fracture Repair in Severe Combat Trauma**. Military Medicine. 2015. v. 180.n. 3. p.315. DOI: 10.7205/MILMED-D-14-00345.

KENNEDY, Carrie H.; Moore, Jeffrey L. (2010). **Military Neuropsychology.** Springer Publishing Company. pp. 115–. ISBN 9780826104496. Retrieved 30 April 2013.

KRAUS JF, RICE TM, PEEK-ASA C, MCARTHUR DL. **Facial trauma and the risk of intracranial injury in motorcycle riders.** Ann Emerg Med. 2003 Jan;41(1):18-26. PubMed PMID: 12514678.

LOPES ALBUQUERQUE CE, NOGUEIRA ARCANJO FP, CRISTINO-FILHO G, MONT'ALVERNE LOPES-FILHO A, CESAR DE ALMEIDA P, PRADO R, PEREIRA-STABILE CL. **How safe is your motorcycle helmet?** J Oral Maxillofac Surg. 2014 Mar;72(3):542-9. doi: 10.1016/j.joms.2013.10.017. Epub 2013 Oct 31. PubMed PMID: 24326016.

MACEDO, K.C. **Características clínicas e epidemiológicas de crianças e adolescentes com traumatismo cranioencefálico leve e análise de fatores associados à fratura de crânio e lesão intracraniana.** 2006. 122f.Dissertação. Faculdade de Medicina.Universidade Federal de Minas Gerais. Belo Horizonte. 2006.

MAGALHÃES,A.L.G.; DE SOUZA L.C.; Faleiro,R.M.; TEIXEIRA,A.L.; MIRANDA,A.S. **Epidemiology of Traumatic Brain Injury in Brazil.**Rev Bras Neurol. v.53, n 2 p.15-22, 2017.

MOHER, D., Liberati, A., TETZLAFF, J., Altman, D.G., GROUP, P., 2009. **Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement.** PLoS Med. 6 (7), e1000097. http://dx.doi.org/10.1371/journal.pmed.1000097.

OCHS, M.W.; TUCKER,M.R. Tratamento das Fraturas Faciais. In: PETERSON, L J; ELLIS III, E; HUPP,J.R.; TUCKER,M.R. **Cirurgia Oral e Maxilofacial Contemporânea.**Rio de Janeiro. Elsevier, 2005.cap.24,p. 559-590. ISBN 85-352-1539-5.

OLIVEIRA, I.B.; OLIVEIRA, A.B.A.; GOES,K.O.; MELO, L.A. **Traumatismo cranioencefálico: considerações anatomofuncionais e clínicas.** Revista Saúde e Pesquisa. Jan./abr.2010. v. 3. n. 1. p. 99-106. ISSN 1983-1870.

PAPPACHAN, B.; ALEXANDER, M. **Correlating Facial Fractures and Cranial Injuries.** Journal Oral Maxillofacial Surgery.2006. v. 64. p.1023-1029 DOI:10.1016/j.joms.2006.03.021.

PEIXOTO, R. M**. Lesões encefálicas: Definições, perspectivas e repercussão social.** 2015. 27f. Manuscrito. Pós Graduação em Neurociências. Universidade Federal de Minas Gerais. 2015.

PERVEZ, M.; KITAGAWA, R.S.; CHANG, T.R.**. Definition of raumatic Brain Injury, Neurosurgery, Trauma Orthopedics, Neuroimaging, Psychology, and Psychiatry in Mild Traumatic Brain Injury**. Neuroimag Clin. 2018. v.28. P.1-13. DOI: https://doi.org/10.1016/j.nic.2017.09 .010.

POWERS,M.P; SCHERER,M.S**. Initial Management of the Trauma Patient.** In: MILORO,M..; GHALI,E.; LARSEN, P. E.; WAITE, P. D.. Peterson's Principles Of Oral And Maxillofacial Surgery. 2 ed. BC Decker Inc ,2004.cap. 18, p. 328-356. ISBN 1-55009-234-0

PULJULA J, CYGNEL H, MÄKINEN E, TUOMIVAARA V, KARTTUNEN V, KARTTUNEN A, HILLBOM M. **Mild traumatic brain injury diagnosis frequently remains unrecorded in subjects with craniofacial fractures**. Injury. 2012 Dec;43(12):2100-4. doi: 10.1016/j.injury.2012.04.010. Epub 2012 May 1. PubMed PMID: 22552039.

RAJANDRAM R.K.; SYED OMAR S.N.; RASHDI M.F.N.; ABDUL JABAR M.N. **Maxillofacial injuries and traumatic brain injury-: a pilot study**. *Dent Traumatol*. 2014. v.30(2).p.128–32. DOI: 10.1111/edt.12052

RAZAK,N.A.; NORDIN,R.; ABD RAHMAN, N.A.; RAMLI, R. **A retrospective analysis of the relationship between facial injury and mild traumatic brain injury**. Dental Traumatology. 2017. v.33. p.400–405. DOI:10.1111/edt12355.

SALENTIJN, E.G.; Collin, J.D.; BOFFANO, P.; FOROUZANFAR, T. **A ten year analysis of the traumatic maxillofacial and brain injury patient in Amsterdam: Complications and treatment.** Journal of Cranio-Maxillo-Facial Surgery. 2014. v.42.p.1717-1722. DOI: http://dx.doi.org/10.1016/j.jcms.2014.06.005.

SCHEYERER, M.J.; DÖRING, R.; FUCHS, N.; METZLER, P.; SPRENGEL,K.; WERNER, C.M.L.; SIMMEN, H.P.; GRÄTZ, K.; GUIDO, A. **Maxillofacial injuries in severely injured patients**. Wanner.Journal of Trauma Management & Outcomes, 2015. DOI 10.1186/s13032-015-0025-2.

SOBIN L, KOPP R, WALSH R, KELLMAN RM, HARRIS **T. Incidence of Concussion in Patients With Isolated Mandible Fractures.** JAMA Facial Plast Surg. 2016 Jan-Feb;18(1):15-8. doi: 10.1001/jamafacial.2015.1339. PubMed PMID: 26448310.

STEPHENS JR, HOLMES S, BULTERS D, EVANS BT. **The effect of direction of force to the craniofacial skeleton on the severity of brain injury in patients with**

a fronto-basal fracture. Int J Oral Maxillofac Surg. 2016 Jul;45(7):872-7. doi:10.1016/j.ijom.2016.01.016. Epub 2016 Mar 10. PubMed PMID: 26972160.

VEERAMUTHU V, HARIRI F, NARAYANAN V, TAN LK, RAMLI N, GANESAN D. **Microstructural Change and Cognitive Alteration in Maxillofacial Trauma and Mild Traumatic Brain Injury: A Diffusion Tensor Imaging Study.** J Oral Maxillofac Surg. 2016 Jun;74(6):1197.e1-1197.e10. doi: 10.1016/j.joms.2016.01.042.

WANYURA H, KAMIŃSKI A, STOPA Z. **Three-layered osteodural plasty for severe anterior skull base and facial injuries. Report of eleven cases.** Neurol Neurochir Pol. 2014 Jan-Feb;48(1):8-14. doi: 10.1016/j.pjnns.2013.03.003. Epub 2014 Jan 23. PubMed PMID: 24636764.

ŽIVKOVIĆ V, NIKOLIĆ S. **Head injuries in falls from a standing height: do fractures of the orbital roof matter? A prospective autopsy study**. Forensic SciMed Pathol. 2014 Dec;10(4):483-6. doi: 10.1007/s12024-014-9583-2. Epub 2014 Jul16. PubMed PMID: 25027415.

ATTACHMENT

Table 1: Studies that associated maxillofacial injuries associated with traumatic brain injury.

AUTHOR	POPULATION (N)	MEAN AGE	STUDY DESIGN	FMF CLASSIFICATION	CAUSE OF TBI	TBI CLASSIFICATION AND TBI FEATURES	MAIN FINDINGS
(Rajandram, R.K. et al, 2013)	11,294 patients	29.5	Retrospective study	Upper-face fracture,Mid-face fractures, Lower-face fractures	Motor vehicle crash, Fall, Assault, Industrial injury, Sport injury	Mild, Moderate, Severe concussion, brain contusion, focal injuries, diffuse injuries and traumatic subarachnoid hemorrhage.	Patients with maxillofacial injuries are at risk of acute or delayed traumatic brain injury. All patients should always have proper radiological investigations
(Grant, A.L. et al,2012)	100 patients	34.1	Prospective study	Le Fort II, Le Fort III Nasal, Mandibular, Zygomaticomaxillary, Orbital floor, Nasoorbitoethmoid, Frontal sinus, Zygomatic arch, Maxillary sinus and Combined	Assault, Fall, Motor Vehicle Accidents, Sports related,Blunt trauma, Crush	Minor and major brain injuries	Facial fractures are often associated with brain injury and high level of suspicion is warranted for minor traumatic brain injuries.
(Keller, M.W. et al, 2015)	5,934 military	25.0	Retrospective study	Orbit, Maxilla, Mandible Frontal, sinus, Nasal, Zygoma	Blast, Improvised explosive device, Mortar, Landmine, Rocket-propelled grenade, Grenade, Gunshot wound	Not mentioned	The results of this study suggest that facial fracture repair is safe in patients with a positive A. baumannii and TBI was common among service members with severe combat trauma and maxillofacial injury.

Fonte: Elaborate by author

AUTHOR	POPULATION (N)	MEAN AGE	STUDY DESIGN	FMF CLASSIFICATION	CAUSE OF TBI	TBI CLASSIFICATION AND TBI FEATURES	MAIN FINDINGS
(Veeramuthu V. et al, 2016)	41 patients	27.3	Prospective study	Tissue or muscle, Facial bone fracture and Mixed injuries	Road traffic accidents	Loss of consciousness and Post-traumatic amnesia	The presence of MF trauma can predict and possibly influence the neurocognitive outcome over time in patients with mTBI.
(Puljula J. et al, 2012)	194 subjects	_	Retrospective study	Facial, Nasal, Orbital Maxilla, Zygomatic, Mandible and Multiple locations	Traffic, Fall, Intentional Sport and Alcohol-positive	Moderate-to-severe and Mild	More attention should be paid to documentation of TBI in subjects with craniofacial fractures.Regular seminars of signs and symptoms of TBI should be mandatory for emergency room personnel.
(Salentijn E.G.et al, 2014)	579 patients	_	Retrospective study	Nerve injury,Visual deficiency, Facial bone defect, Soft tissue damage, Occlusal disturbance,Hemorrhage	Traffic accident, Violence, Fall	Mild, moderate or severe	Optimal treatment of maxillofacial injuries may be compromised in some cases when deference to neurosurgical concerns is necessary, a variety of complications frequently arise and often necessitate further treatment and prolonged hospitalisation.

Fonte: Elaborate by author (continuation)

AUTHOR	POPULATION (N)	MEAN AGE	STUDY DESIGN	FMF CLASSIFICATION	CAUSE OF TBI	TBI CLASSIFICATION AND TBI FEATURES	MAIN FINDINGS
(Cavalcante, J.R. et al, 2012)	272 patients	_	Prospective study	Lip injury, Eyelid injury, Facial injury and Extensive injury in the face	Fall on dirt road, Fall on paved road, Collision with car Collision with motorcycle, Collision with bicycle, Collision with animal, Collision with pedestrian	Moderate traumatic brain injury	Individuals in the most productive age group are most affected and It is important to alert the population regarding the severity of injuries likely to occur with motorcycle accidents.
(Živković, V. et al, 2014)	50 cases	70.0	Prospective study	Orbital roof fractures	Ground level falls	Periorbital hematoma, Conjunctival hemorrhages, contusions, Fractures of skull, Subdural and Epidural hematoma; Skin lacerations.	In autopsy in cases of fall,the occurrence of orbital roof fractures was not significantly associated with concomitant skull fractures and brain injuries.
(Kraus, J.F. et al, 2003)	5,790 motorcycle riders	28.7	Cohort	Mandible, Maxilla, Nose Zygoma, Orbit, All bones	Traffic accident and Violence	Skull fracture	The findings support previous research demonstrating an association between facial fractures and traumatic brain injury.

Fonte: Elaborate by author (continuation)

AUTHOR	POPULATION (N)	MEAN AGE	STUDY DESIGN	FMF CLASSIFICATION	CAUSE OF TBI	TBI CLASSIFICATION AND TBI FEATURES	MAIN FINDINGS
(Chu, Z.G. et al, 2011)	221 cases	35.0	Retrospective study	Mandible: Symphysis, Parasymphysis, Body, Ramus, Condyle, Maxilla: Posterolateral wall of maxillary sinus, Anterior wall of maxillary sinus, Medial wall of maxillary sinus, Palatine process Zygoma: Body, Arch Orbit: Lateral wall, Medial wall, Inferior wall, Superior wall	Earthquake	Frontal, Parietal,Temporal,Occipital and Sphenoid bone; Intracranial injury:hematoma, haemorrhage,Pneumocephalus, Cerebral edema,Cerebral contusion and laceration.	Our results indicate that the cranio-maxillofacial trauma arising from the massive Sichuan earthquake had some characteristic features, and a significant number of individuals had the potential for combined cranial and maxillofacial injuries, successful management of which required a multidisciplinary approach.
(Huang, W. et al, 2012)	45 patients	27.9	Cohort	Condyle-ramus	Not mentioned	Severe Tramatic Brain Injury	The patients with severe TBI and mandibular fractures exhibit increased fracture healing as evidenced by early callus formation.
(Fares, Y. et al, 2014)	417 casualties	27.0	Prospective study	Facial nerve,Eyes, Skin,soft-tissue lesions	Cluster munitions	pTBI, cTBI and scalp	Due to cluster bombs can inflict injuries to the head and face regions upon and patients suffer from multiple injuries at the same time. Psychological tribulations are often strong post incidence.

Fonte: Elaborate by author (continuation)

AUTHOR	POPULATION (N)	MEAN AGE	STUDY DESIGN	FMF CLASSIFICATION	CAUSE OF TBI	TBI CLASSIFICATION AND TBI FEATURES	MAIN FINDINGS
(Pappachan, B. et al, 2006)	12,329 patients	32.0	Retrospective study	Fractures of the maxilla at Le Fort I,II,III; Maxillary and palatine bones. Fractures of the mandible, fractures of the zygoma and orbit.	Motorcycle accident,motor vehicle accident, road traffic accident	Cranial bone fractures: frontal, temporal, sphenoid, parietal, occipital, and a combination of these; Concussion; Intracranial injuries: cerebral contusion and laceration; hemorrhage	When considering the individual facial bones were able to single out the central midfacial bone to be associated more commonly with head injury.
(Cossman, J.P. et al, 2014)	1,171 patients	38.1	Retrospective study	Orbital roof fractures	Fall, Assault, Motor vehicle collision, Bicycle collision, Motorcycle collision, Pedestrian struck	Neurologic, ophthalmologic, and skeletal injuries	Orbital roof fractures represent a unique class of craniofacial injury.The data also show that almost two- thirds of orbital roof fractures are associated with traumatic brain injury.
(Scheyerer, M.J. et al, 2015)	487 patients	44.0	Retrospective study	Orbital Region,Maxilla,Zygoma, Nasal Bones, Sphenoid bone,Mandible,Frontal bone,Teeth, Petrosal bone,Temporomandibular joint and LeFort-Fractures I,II,III.	Falls,motor vehicle collisions, bicycle accidents, pedestrian-car-accidents and assaults	Intracranial bleeding	MFI are often associated with a risk of other serious concomitant injuries, in particular TBI. The diagnosis and treatment of such concomitant injuries have the potential to be overlooked or delayed in severely injured patients.

Fonte: Elaborate by author (continuation)

AUTHOR	POPULATION (N)	MEAN AGE	STUDY DESIGN	FMF CLASSIFICATION	CAUSE OF TBI	TBI CLASSIFICATION AND TBI FEATURES	MAIN FINDINGS
(Lopes Albuquerque, C.E. et al, 2014)	253 motorcyclists	29.64	Cohort	Mandible, midface, upper face and facial lacerations	Motorcycle accident	Loss of consciousness, loss of memory, alteration in mental state, focal neurologic deficits transient or not.	The large part of motorcyclists had MF and TBI, and crash helmets did not always offer adequate protection against MFI, especially open-face helmets.
(Huang L.K. et al, 2017)	1,649 patients	53.1	Cohort	Facial wound, Tooth rupture, Epistaxis, Fractures of the Upper face, Midface,Lower face, Orbital fracture, Fracture of the Nasal bone, Zygoma, Maxilla, Mandible.	Fall from elevation, Motorbike collision	Intracranial hemorrhage, Skull fracture, Facial swelling/hematoma	TBI patients with risk factors have a higher probability of concomitant MF. Fractures of the lower face and orbit are easily overlooked but often require surgical intervention. Therefore, imultaneous head and facial CT scans are suggested in TBI patients.
(Czerwinski, M. et al, 2018)	181 medical records	35.0	Retrospective study	Mandible fractures: parasymphyseal and symphyseal, condylar, subcondylar, condyle, and condylar neck.	Motor-vehicle collision, fall from height, struck by vehicle, gunshot wound.	Mild, moderate and severe TBI, hemorrhage, hematoma, diffuse axonal injury.	Was suggest an algorithm, based on the results of the study, to help determine the need for head CT scans in trauma patients who sustain a mandibular fracture.

Fonte: Elaborate by author (continuation)

AUTHOR	POPULATION (N)	MEAN AGE	STUDY DESIGN	FMF CLASSIFICATION	CAUSE OF TBI	TBI CLASSIFICATION AND TBI FEATURES	MAIN FINDINGS
(Stephens,J.R. et al, 2016)	81 patients	30.0	Cohort	Lateral supraorbital rim collapse, orbital roof fractures, inferior orbit, superior orbital rim, mid-third of the orbital roof fracture,sphenoid wing	Road traffic collision and Fall from height	Frontobasal fractures	The patients in this study who received a predominantly anterior impact to the fronto-basal region sustained a significantly less severe brain injury compared to those who received a predominantly lateral impact.
(Holmgren, E.P. et al, 2004)	9,871 patients	34.1	Retrospective study	fractures of : Nose, Orbit, Maxilla, Mandible, Zygoma, Le Fort fractures and Frontal sinus.	Prevalent type of motor vehicle accident	concussions, including those with and without loss of consciousness	The trauma patients who require a head CT will have one or multiple facial fractures. The use of the facial CT in more severely injured patients tended to be delayed and was related to increased hospital and intensive care unit days.

Fonte: Elaborate by author (continuation)

AUTHOR	POPULATION (N)	MEAN AGE	STUDY DESIGN	FMF CLASSIFICATION	CAUSE OF TBI	TBI CLASSIFICATION AND TBI FEATURES	MAIN FINDINGS
(Wanyura, H. et al, 2014)	11 patients	NM	Prospective study	Frontal sinus, supraorbital bar, frontal bone	Impaction with wood in sawmill,Beating – wound from sharp object, Beating, Car accident, Crushed by wooden ball, Beat by horse head, Beat by brunch of a tree.	Concussion, Pneumocranium, LCR leak, epidural haematoma, subdural haematoma.	The three-layer osteodural plasty of severe anterior skull base injuries with the use of autologous bone grafts for the reconstruction of craniofacial skeleton resulted in a good final functional, morphological and aesthetic outcome in all patients.
(Aladelusi, T. et al, 2014)	201 patients	30.3	Prospective study	Soft tissue ,Maxilla, Mandible, Zygoma, Multiple fracture,Naso-orbito-ethmoidal	Road traffic crashes	Mild, moderate, severe head injuries and Cranial fracture.	The study showed a direct relationship between the severity of maxillofacial injury and head, ocular and polytrauma and further emphasizes the need for thorough examination of patients presenting with road traffic crashes related maxillofacial injuries.
(Sobin, L. et al, 2016)	562 patients	27.5	Prospective study	Mandible fractures: body, symphyseal, parasymphyseal, subcondylar, angle, ramus.	Assault, all-terrain vehicle,bike, Sport.	Concussion	The concussive symptoms have a high index of suspicion for mTBI and are associated with isolated mandible fractures was identified.

Fonte: Elaborate by author (continuation)

AUTHOR	POPULATION (N)	MEAN AGE	STUDY DESIGN	FMF CLASSIFICATION	CAUSE OF TBI	TBI CLASSIFICATION AND TBI FEATURES	MAIN FINDINGS
(Gönül, E. et al, 2005)	402 patients	20.0	Prospective study	Orbital bone	Gunshot	Anterior cranial fossa,middle fossa and posterior fossa injuries	The prognosis of the injury depends on the course of the bullet or shrapnel fragment and the interdisciplinary care. An extensive preoperative evaluation of penetrating orbital trauma and a combined ophthalmic and neurosurgical approach are recommended to minimize the morbidity of the patients.
(Razak, N. A. et al, 2017)	361 medical records	33.37	Retrospective study	Facial injury: Abrasion, Contusion/Haematoma, Laceration	Road Traffic Crashes,Sports, Industrial, Domestic, Fall and Assault	mTBI	Mild traumatic brain injury should be suspected in patients with facial injuries and particularly those with lower face lacerations, midface fractures, moderate to severe facial injury and presence of multiple injuries.
(Hammond, D. et al, 2018)	500 patients	NM	Retrospective study	Not mentioned	Not mentioned	Concussion and severe TBI	Awareness of concussion and itsclinical relevance should also be covered for oral and maxillofacial surgeons trainees.

Fonte: Elaborate by author (continuation)

AUTHOR	POPULATION (N)	MEAN AGE	STUDY DESIGN	FMF CLASSIFICATION	CAUSE OF TBI	TBI CLASSIFICATION AND TBI FEATURES	MAIN FINDINGS
(Cai, S.S. et al, 2017)	159 patients	39.9	Retrospective study	Frontal sinus: Isolated anterior table, Isolated posterior, Both tables; nasofrontal outflow tract.	Motor vehicle crash, Fall, Motor cycle crash, Pedestrian struck and Assault	Contusion, traumatic subarachnoid hemorrhage, subdural hematoma, epidural hematoma, intraventricular hemorrhage,cerebrospinal fluid, Skull base fractures.	The frontal sinus volume is inversely correlated with the severity of intracranial pathology following craniofacial trauma. The findings are consistent with the “crumple zone” hypothesis and suggest that the frontal sinus likely plays a role in mitigating intracranial injury. Furthermore,frontal sinus volume is significantly different between male and female patients.

Fonte: Elaborate by author (conclusion)