AN ATYPICAL AIR BAG INJURY?

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ABSTRACT

The air bag is a passive safety device capable of saving many human lives each year. However, in a certain number of cases, it is itself the source of injuries to the occupants of a motor vehicle, mostly of cutaneous burns. The case describes peculiar abrasions to the enamel of the teeth scraped by the air bag, in particular atypic lesions involving the upper arch showing buccal rings of demineralization associated with roughness of the enamel that progressively assume a trend of fine parallel oblique striae from bottom to top and from left to right, as literature describes for cutaneous burns due to air bag insult.

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Key words: air bag, tooth injuries, friction burns

INTRODUCTION

The air bag is a passive safety device consisting of a cushion of nylon fabric and rubber that inflates and positions itself between the passengers and the internal parts of a motor vehicle's body when its sensors detect sudden longitudinal deceleration similar to that which occurs when a vehicle traveling at 20-30 km/h[1,2] collides with a barrier. The basic version, for the driver, anticipates that a folded bag inside the steering wheel, with a volume of 40 or 70 litres, will inflate in the span of 30-50 milliseconds (when the passenger's body has already come forward about 20 cm) and deflate within 2 seconds. The speed obtained during inflation varies from 160 km/h[3] to 330 km/h,[1] with the production of a sound wave that can reach 150-170 decibels[2], a value that, however, does not exceed the rupturing threshold of the tympanic membrane.[4]

The present work describes an unusual expression and localization of typical air bag injuries, friction burns, which are customarily found on the face. In this particular case, tooth enamel was affected, an occurrence that, as far as we know, has never been reported in the literature.

ADVERSE EFFECTS OF AIR BAG DEPLOYMENT

The introduction of the air bag into standard automobiles, first represented in Europe by the Mercedes Class S in 1982,[5] contributed to saving a considerable number of the lives of those involved in potentially lethal accidents. An approximation of this device's effectiveness in the United States is roughly 14,000 deaths prevented during the period between 1987 and 2003.[6]

Nevertheless, over the course of time, injuries to motor vehicle occupants began to be recorded, brought about precisely by the opening mechanism and operation of the air bags.[2] The literature reports the occurrence of cutaneous abrasions in 68.6% of the cases of subjects that display air bag injuries, either alone or in association with other injuries. Contusions involving the cervical column and temporomandibular joint (TMJ),[7] appear in 37.8% and cutaneous lacerations were observed in 18.2% of cases (a pressure of 7 atmospheres being sufficient to lacerate intact skin[2]). Burns constitute about 8% of air bag injuries, although less independent statistics maintain it as a slightly lower rate: the incidence verified by the automobile manufacturer Daimler-Chrysler is equal to 5%.[3]

Descriptions of fracturing injuries (3.2%) to the sternum, clavicle, ribs and bones of the face,[8] which include nasal and orbitozygomatic fractures, have also been reported. A force of 10-35 kg and 90-200 kg respectively was judged sufficient to produce these last two injuries.[1] Damage to the auditory apparatus and eyes is also frequently noted. Barotraumas with a residual permanent loss of hearing and peripheral vertigo have commonly been described,[8] as well as a range of ocular injuries, the most notable being subluxation of the lens, vitreous hemorrhage, traumatic iritis,[8] and retinal detachment in 1.8% of cases.[2] Also mentioned are serious visceral thoracic traumas, represented by pericardiodiaphragmatic ruptures[9] and pulmonary traumas,[9] as well as respiratory disorders in asthmatic subjects.[8]

CUTANEOUS BURNS

Of the above-described type of injury associated with air bag deployment, it seems worthwhile to examine burn injuries more closely. These most frequently affect the skin superficially, but second-degree burns are sometimes found. The aetiopathogenetic mechanism that causes them is multifactorial (chemical, thermal and physical) and can be understood through knowledge of the device's operational dynamics.

The inflation of the bag is due to the release of a gas, nitrogen, which is produced when an electric impulse triggers the pyrotechnic charge of a cartridge of 70 grams of sodium azide (the propellant) resulting in an exothermic reaction.[2] Along with the nitrogen (96%), carbon dioxide (3%) is released, as well as a mixture of gases and particulate compounds (1%), including carbon monoxide, nitric oxide, ammonia, benzene, toluene, ethylbenzene, xylene and hydrocarbons (methane, ethane, ethylene, etc). Moreover, an exceedingly basic and corrosive aerosol is generated in small quantities, made up of sodium hydroxide, sodium carbonate and metal oxides.

Burns, then, are attributable to three causes relating to the nature of the injury:

- caustic chemical burns, caused by the particulate material (in a manner that has still not been entirely explained) and by the pH of the mixture of the substances produced;
- thermal burns, produced both directly by the high temperature of the gases released and indirectly by the melting of synthetic clothing (especially polyester);
- friction burns (also the source of abrasions to the cornea and eyelids).

At the cutaneous level, permanent pigmentations produced by irritant dermatitis are frequently manifested, provoked by the combination of gases, abrasive dusts and talc discharged under great pressure. The injured consequently complain of itching, burning and stinging. The thorax, arms and face can present erythema, oedema and purpura. As far as is now known, it does not seem that these dermatides admit an allergic origin.

Chemical burns occur in the moment in which the dispersion of a white dust[9] settles and comes into contact with a liquid like sweat, producing an alkaline solution that has a burning effect. If the pulverulent residue penetrates into the eye and is dissolved by the tears, the solution can cause alkaline keratitis. The treatment to follow in such cases is a thorough washing with saline solution, to be repeated if necessary after having checked the eye's pH level, since it may rise again during the 30 minutes following the irrigation of the eye.[2] For superficial cutaneous chemical burns, treatment by the application of topical corticosteroids is sufficient.

The arms and thorax are the sites most affected by burns of the thermal kind. Superficial burns usually appear pink or pale red with the formation of painful blisters, while the deep burns are mostly whitish, asymptomatic and lacking blisters.[8]

Friction burns have instead the characteristic appearance of "numerous, fine, parallel superficial erosions on an erythematous base"[8] that are localized, usually on the face, chin and neck.[2] They are produced when the bag, unfolding during the opening process, rubs against the skin with an effect similar to a slap received "edgewise".

CASE REPORT

A 25-year-old male, while driving his own motor vehicle with his seatbelt fastened, was involved in a frontal collision owing to another automobile's incursion into his lane. Following the crash, the air bag deployed, hitting the driver and preventing his impact against the windshield. Subsequent to the accident, he was transported to a nearby emergency room where he was examined and treated. The emergency room records reported during the general exam: "... craniocervical and facial trauma ... post-traumatic epistaxis ... haematoma on the lips. Wounds (superficial) to the left nasal vestibule and the upper gingivolabial fornix. Does not require sutures".

In particular, the presence of a lacerated and contused wound on the upper left gingivolabial fornix and of abrasions on the buccal side of the enamel of 12, 11, 21, 22, 23, 24, 25 was noted. An orthopantomograph (OPG) was also taken, showing absence of periapical-radicular lesions at that time.

Seven months later the subject came under our observation while making a medicolegal visit in order to evaluate the damage resulting from this incident. At this time, the presence of lesions on the enamel of some maxillary teeth was noted (Figs. 1 and 2). The case history, thoroughly investigated, did not reveal any relevant element in this regard. In particular, the following explanations were refuted: a history of anorexia with induced vomiting or gastroesophageal reflux (furthermore, the palatal surfaces of the maxillary teeth did not present a smooth shiny look and tissue loss, both typical of

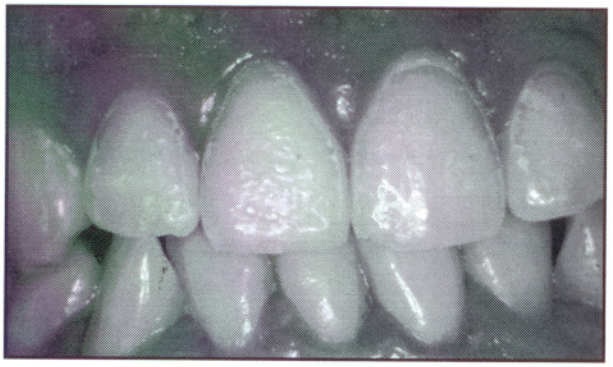

Fig.1: *The roughness of the enamel*

Fig.2: *The abrasive lesions of the teeth*

such conditions); eating habits including the excessive consumption of acidic foods like lemons or citrus juices; former traumas to the oral and maxillofacial zones. Moreover, there was no history of orthodontic treatment or other dental restorative treatment to 12 - 25. Unfortunately, previous dental treatment records were not available.

Our examination furnished the following findings:

- From 12 to 25: buccal rings of demineralization associated with roughness of the enamel that progressively from the first to the second maxillary hemiarch assume a trend of fine parallel oblique striae from bottom to top and from left to right. Nil of note on the palatal surfaces.
- 11: fracture of the incisal enamel.
- 21: fracture of the mesial edge limited to the enamel.
- Between 11 and 41: overjet of 1 mm; overbite of 2 mm.
- The mucosa of the upper left vestibular fornix and the attached gingiva were normotrophic, without cicatricial adhesions. Absence of functional deficiencies in homolateral movement of the upper lip.
- Electrical vitality test using a Kerr Vitality Scanner* of the pulpal sensitivity of 12 through 25 showed values within the norm (in the following medical inquiry, an increased sensitivity to thermal stimuli was reported by 12 through 25).
- No pathological findings for the lower teeth.

MEDICOLEGAL CONSIDERATIONS

The reported case concerns peculiar dental lesions of the enamel, resulting from an accident in which the air bag deployed. The injuries reported by the driver consisted of craniocervical and contusive facial trauma, with post-traumatic epistaxis, hematoma on the lips and superficial wounds to the nasal vestibule and the upper gingivolabial fornix, not requiring sutures. Abrasion of the buccal enamel of 12 - 25 was observed in the emergency room. Seven months later, during the medicolegal exam to evaluate injuries, clinical observations emphasized the persistence of abrasive lesions on the enamel of the teeth cited above. However, doubt persisted about whether they could be ascribed to the car crash in question and therefore also about the possibility and degree of reimbursement for the aftereffects suffered by the patient.

Since no reference to any such air bag-related injury could be found in the literature, these clinical observations became the object of a medicolegal study, utilizing the classic principles of causation. The topography of the lesions corresponded to what was recorded in the emergency room about distress to the vestibular mucosa of the maxillary dental arch. Endogenous causes were excluded, since the remaining teeth do not present with an appearance that could be traced to a developmental disturbance such as amelogenesis imperfecta. The lesions do not present the smooth appearance resulting from low impact mechanical insult, such as due to the brushing of the teeth with baking soda.[10] Nor do the palatal surfaces of the injured teeth show alterations that could be ascribed to the localized action of gasses or liquids of gastric origin. The inferior opposing teeth also appear without buccal demineralization resulting from potential atypical eating habits, through prolonged contact with acidic foods (for example, slices of a citrus fruit held in the left fornix), suggesting that they have been somehow protected from the injury by the lower *labium*.

The air bag deployment with high-pressure contact has been shown to cause injury: the roughness of

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the enamel was possibly produced by the abrasive mechanical action of the air bag's synthetic fabric rubbing against the teeth, producing thermal energy through friction. This energy acted together with the high temperature of the released gasses and the aggressive chemical action of the aerosol in which the subject found himself immersed. In effect, the premolars presented typical lesions, "numerous, fine, parallel erosions", absolutely analogous to those that are found described in the literature in the case of friction burns on the skin, whose appearance could be defined almost pathognomonic of the air bag abrasion. Moreover, no pure blunt trauma could produce such a pattern of lesion.

It has been suggested that the dynamics of air bag deployment follow situational dynamics, with injuries being more frequent among people of short stature (158-162 cm), in which the driver is positioned at a distance of around 25 cm or less from the wheel.[1] This is because the lower portion of the air bag, given the lack of space available, is "compressed" between the thorax and the steering wheel, and is forced to expand in a primarily vertical direction, from bottom to top, so that the person's face is hit not from the front, but "edgewise", resulting in the production of the cutaneous abrasions and lacerations. Such wounds were also correlated with the shape of the air bag when it is inflated. The subject in this instance was marginally taller than this height range. It has also been reported that bags that display a concavity at the center produce facial lesions less easily, since they have a range of action in expansion toward the subject of around 25 to 33 cm, in contrast to those bags that do not display a concavity, where the values are respectively of around 38 to 50 cm.[1]

In our opinion the combination of mechanical, chemical and thermal energy simultaneously contributed to the production of the peculiar parallel erosion of the enamel due to the deployment of the airbag and consequent impact on the exposed superior teeth, even we do not definitely know the way such effect can be produced by a brief and sudden contact with the dental surface. Further study is needed to confirm the aetiology and give a clear explanation of the mechanism of production of the injury.

In this instance the causal relation between the incident and the established effects on the tooth enamel was considered sufficiently proven, not only by the immediately suggestive appearance of the parallel and seriate erosions, but especially by the clinical history and its bibliographic correlations, notwithstanding that no case report has been found that indicates the recurrence of such lesions among those described by the literature as connected to air bag deployment. From the perspective of compensation, the application of porcelain veneers to 12 through 22 and of composite vestibular fillings in 23, 24 and 25, and their periodic renewal as required, was considered sufficient to completely correct the damage.

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