NEMESIS
Negative Effects in Medical Sciences Oral and Maxillofacial Surgery
UCL PRESSES UNIVERSITAIRES DE LOUVAIN

# Jael's syndrome: knife blade impacted in the facial skeleton: an illustrated case report and a review of literature

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## Abstract

**Objective**: This article focuses on the penetrating trauma of the facial mass caused by the knife with retention of the blade fractured in the facial skeleton.

**Case report**: We describe preoperative, intra-operative and post-operative outcomes of the knife stabbing in the face, and of the surgical removal of the broken 8cm long blade using two dimensional, and tridimensional computed tomography, and clinical iconography

**Conclusions**: We provide the readership with a broader perspective on iatrogenic facial trauma caused by blades with examples from history of medicine, with biomechanical focus, as well as a review of literature on the management, and on the surgical treatment outcomes of such infrequent emergency in maxillofacial surgery.


**Keywords**: knife injury, Jael syndrome, penetrating foreign body, face, biomechanics

## Introduction

Nowadays, penetrating injuries in the maxillofacial skeleton are a rare event and not much reported in the scientific literature [1, 2] and particularly when it affects the maxillary sinus [2, 3]. These events can occur at any stage of life and have a heterogeneous etiology [4].

The available literature does not provide detailed epidemiologic data on penetrating facial trauma involving knives, and it consists only of case studies or single case series [5] especially when the knife remains retained in the patient [6-9]. This tends to show that most centers have very limited experience with these injuries. However, some centers can collect more experiences without publishing, depending on the local geopolitical and/or social context.

From a historical point of view, the wounds by sharp force have been with humanity since the beginning of the production of blades. The production of weapons / tools such as blades have continued to improve throughout history and the advancement of technology. Knives have been found since the Paleolithic period when blades were initially made of stone before being made of metal in the Bronze and Iron Ages [10]. Knives as we recognize them were first made from copper and bronze between 3000 and 700 BC, and some are very similar in design to those used today [11].

*"Nowadays, blades are mainly made of ferritic stainless steels, but they can also be found in ceramics, polymers"* [12].

For this reason, the doctors of the time, confronted with the injuries that blades generated and accumulated a great experience in the treatment of sharp trauma through the multiple wars, before it was gradually replaced by injuries caused by high velocity explosive weapons with other inherent complications. [13].

This led to the development of a medicine that could be called war medicine and contribute to the development of medicine. This medicine treated all kinds of injuries caused by blunt and sharp force trauma (Figure 1). It is articulated around the accompaniment and monitoring of the patient and the management of bleeding, wound care management fracture... The "wound man" is an illustration commonly reproduced in surgical works of the Middle Ages (constitute largely of penetrating sharp trauma caused by various types of blades). This illustration also shows that already the doctors of the time were interested in the mechanisms of the wounds to look after the polytraumatized patients [13]. This principle is still relevant in trauma today and is used in trauma management algorithms such as the Advanced Trauma Life Support ATLS [14].

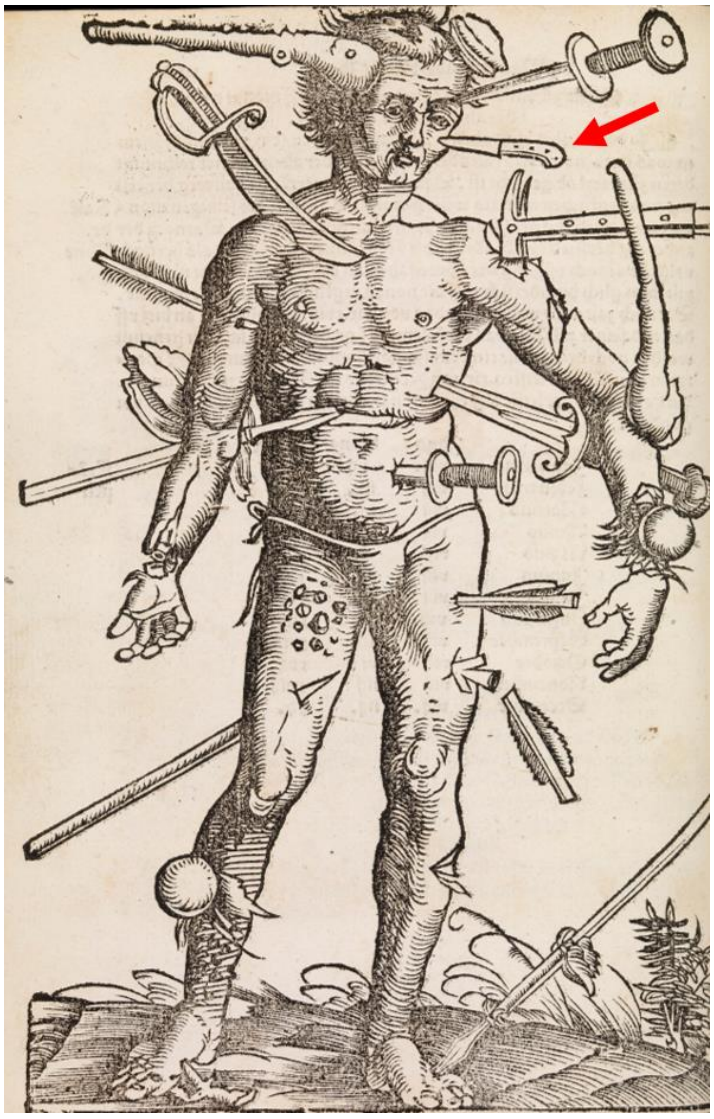


**Fig. 1. The "wounded man".** Illustration found for the first time in surgical textbooks schematizes the various injuries that could be inflicted on a medieval man during a battle (first time by Johanne de Ketham Venis 1492). Despite these injuries, however, the Wounded Man is still depicted alive as standing [15] This reaffirms the fact that the wounds had healing potential [15]. Here is the version from Hans von Gersdorff's Feldtbuch der Wundartzney (Strasburg, 1519). Red arrow illustrates the wound performed by a knife under the left orbit, and corresponding to our clinical case.

Nowadays, these types of injuries caused by knives and other sharp objects are representative of trauma in the civilian context in the course of interpersonal conflicts (criminal and terrorist). This trend can be explained by the wide accessibility of this type of weapon in the civilian environment [16]. A higher incidence is observed in countries with strict gun laws [11, 18]. Thus, we find that sharp force homicide is more common than firearm homicide in Europe, unlike the United States [19-24]. Stabbing is the most common cause of homicide in the UK [25-27]. A 2017 report describes 36,598 incidents, a 22% increase in relation to the previous year [28]. In Belgium, knife fights increased 2.5 times between 2000 and 2020 [29]. Finally, terrorist attacks increasingly involve edged weapons as a primary or secondary weapon. In one study, 1615 patients reportedly presented with intentional (terrorism-related) knife injuries between January 2013 and March 2016 in Israel during the "Knife Intifada" [30].

However, specific penetrating trauma of the facial skeleton is not considered a frequent situation, one of the reasons advanced by some authors is mainly as a result of attempts to protect the face with the hands in self-defense [31].

In cases where the stabbing is intentional to the skull or face, the cases are grouped in the literature under the name of Jael's syndrome [32-35]. It was Jefferson et al., [32] who first described in 1968 a severe craniofacial lesion in a 16-year-old boy impaled on a tent peg that penetrated the orbit and extended to the midbrain referring to the Jael's syndrome [32]. This syndrome refers to a biblical scene of the murder of Sisera (Canaanite commander) by Jael, which thus allowed to deliver the tribes of Israel from the domination of king Jabin, in Judges, IV, v. 21: "Jael, Heber's wife, took a stake from the tent, took the hammer in her hand, came to him gently, and drove the stake into his temple, and it went into the ground. He was sound asleep and weary; and he died."

And although they can be life-threatening when the major blood vessels of the face are affected [1, 36, 37] the mortality from stab wounds in general is known to be relatively low in the medical and forensic literature [17, 26, 38, 39].

However, trauma where knife blade retained in the maxillofacial skeleton is an unusual and spectacular injury especially in Europe. However, surgeons of the head and neck region, including otolaryngologists, neurosurgeons, maxillofacial surgeons, ophthalmologists, plastic surgeons and also radiologists, interventional radiologists, anesthetists, emergency physicians, intensivists, need to be aware of the management and care of these dramatic injuries because of the trend of increasing incidence of these types of injuries [40].

The objective of this article is to review the characteristics, and the management of such injuries through a clinical case.

## Clinical report

The case report concerns a 17-year-old male (with no particular medical history), arrived at the emergency room by ambulance with the presence of a knife blade retained in the face following a dispute in the family context (Figure 2).

**Fig. 2. Patient on arrival at the emergency room with the presence of a knife blade retained in the face and extending into the oral cavity.**
Arrows are showing the lateral edges of the knife in the oral cavity.

## Primary investigation

The primary investigation is based on the ABCDE system based on the Advanced Trauma Life Support (ATLS®) algorithm of the Committee on Trauma of the American College of Surgeons [14].

During the primary investigation the following elements were checked:

A: Airway: there was a presence of abundant but not pulsatile intra- and extra-oral bleeding that could obstruct the airway. The knife blade was situated in the right pharyngeal/tonsil area (Figure 3).

B: Breathing: the O2 saturation of the patient was at 98%

C: Circulation: blood pressure was at200/90, with heavy bleeding, not pulsatile, and the patient remained normo colored.
D: Disability: the Glasgow coma scale was 15/15; the patient presented with hypoesthesia of the left inferior orbital nerve, without diplopia or visual disturbance.
E: Evaluation: deep facial wound of 2 cm with sharp edges was located in the left infraorbital region. Intra-orally, we noted the presence of the retained blade transfixing the hard palate on the medial line around tooth 47 and the knife tip was located in the tonsil area (Figure 3).
Upon primary investigation, there was no significant bleeding, no hemodynamic instability or respiratory distress.

## Secondary investigation

Therefore, the secondary investigation was performed immediately using computed tomography (CT) scan. It revealed the presence of a knife blade of 8.4 x 2 cm retained in the face, with its main axis antero-posterior, superior-inferior and from outside to inside. The blade crossed respectively the anterior wall of the left maxillary sinus, the nasal wall of the left maxillary sinus, the hard palate on its medial line to end in the right tonsillar area. The analysis of the general axis of the blade makes it possible to exclude the damage of large vascular axes, although the important metallic artifact of the knife could have contradicted this certainty (Figures 3-17).

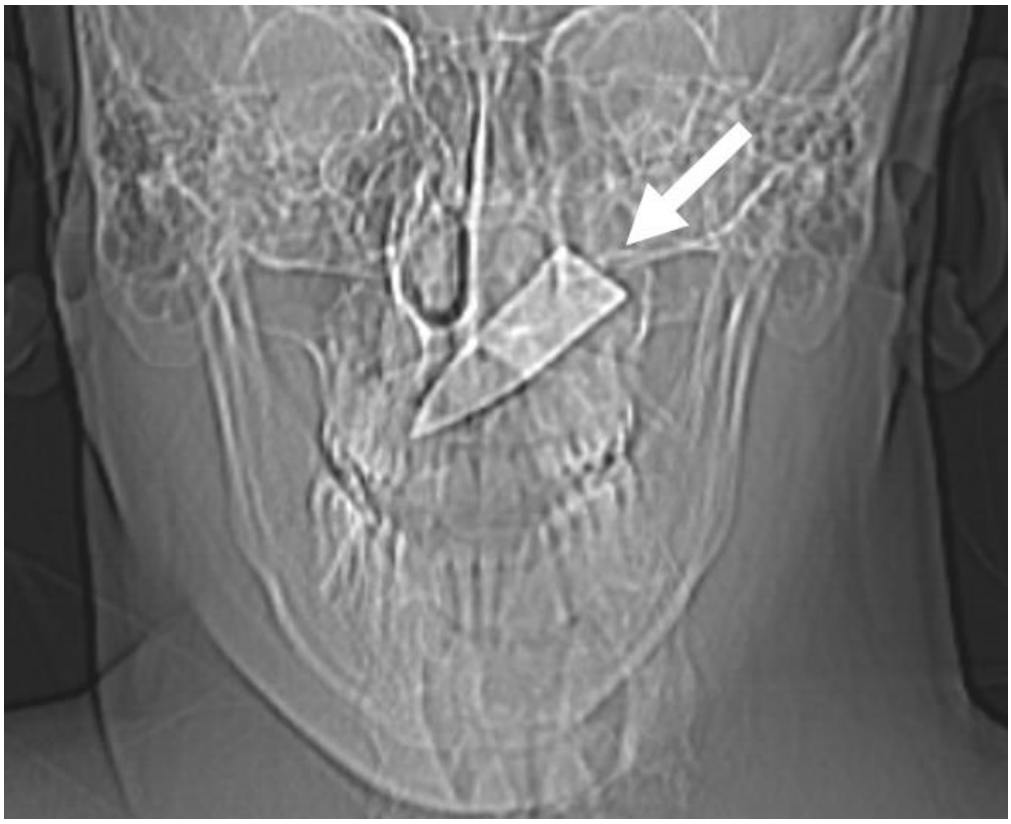


**Fig. 3. CT scan topogram.** Frontal view. Presence of the knife blade with its main axis oriented from left to right, from outside to inside, and from the maxilla to the mandible (arrow).

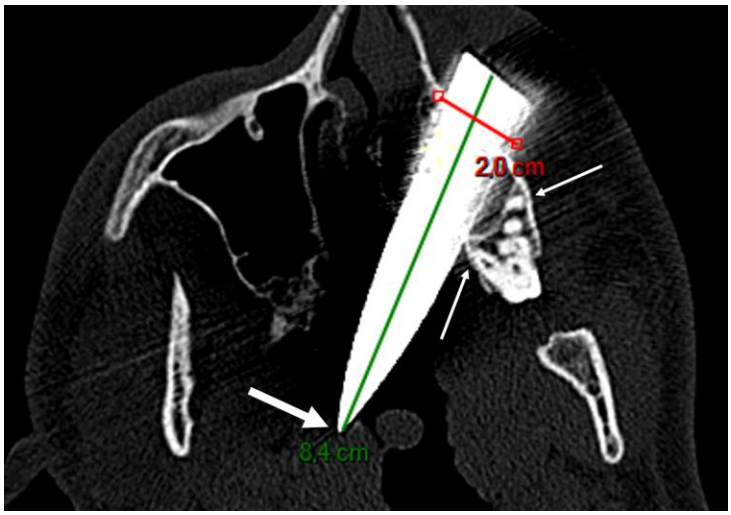



**Fig. 4. CT scan (bone window).** Axial view. Cross section of the blade showing its dimensions 8.4 x 2 cm, and its close relationship with the left molars root apices (thin arrow), and with the right tonsil area (thick arrow).

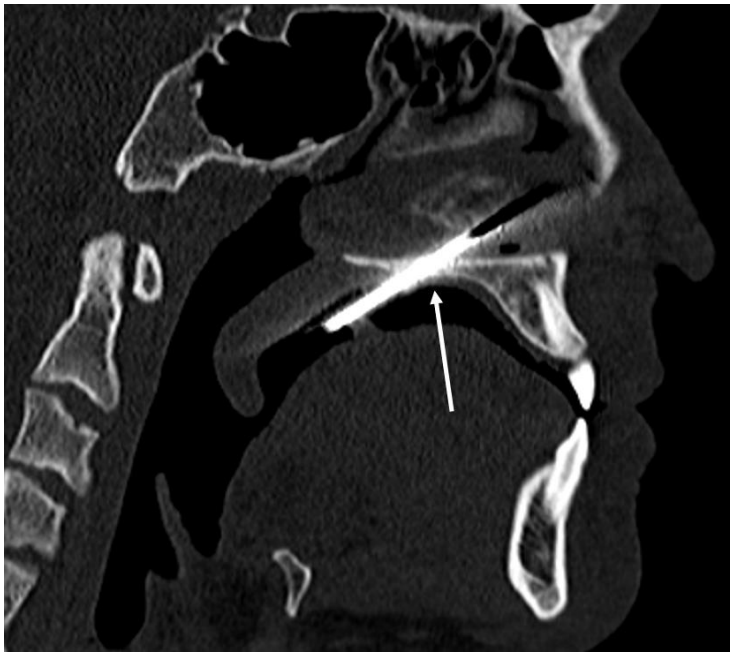


**Fig. 5. CT scan (bone window).** Sagittal view. The blade is crossing the hard palate on the midline (arrow).

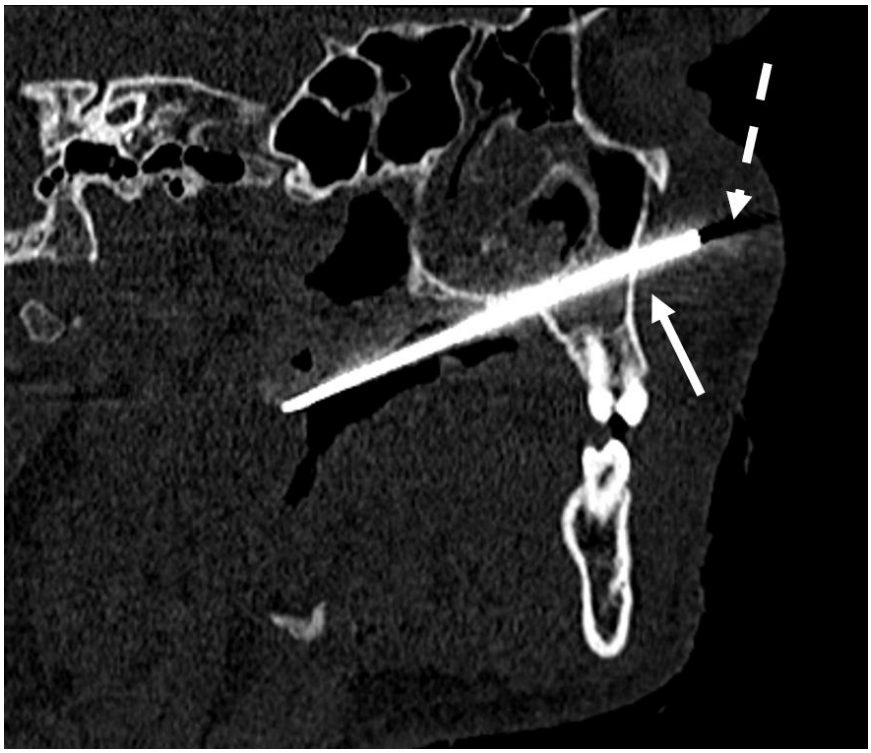


**Fig. 6. CT scan (bone window).** Multi-reformatted view along the blade. The blade crosses the anterior wall of the left sinus (thin arrow) and the hard palate (thick arrow). The origin of the blade protrudes 1 cm from the anterior wall of the left maxillary sinus (arrow), and it is located 1.6 cm deep in the soft tissues of the face (dashed arrow).

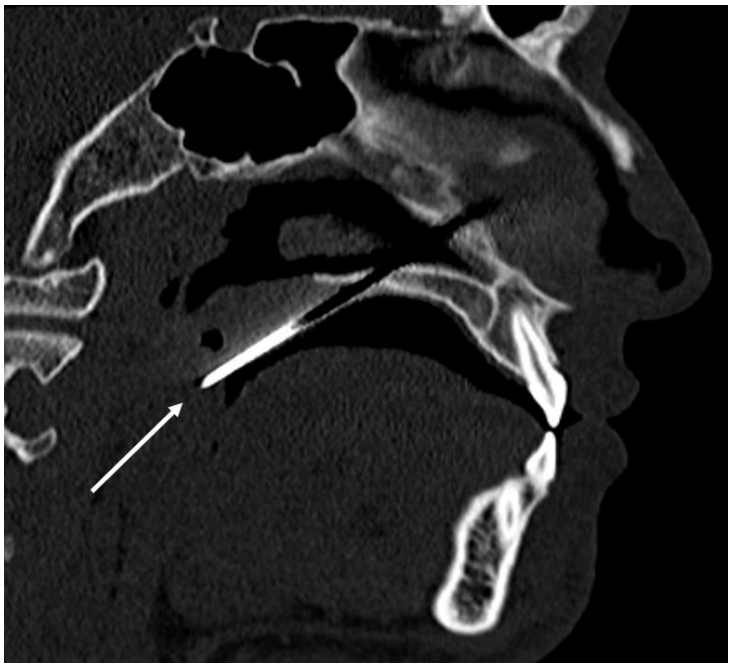


**Fig. 7. CT scan (bone window).** Multi-reformatted view along the blade. The tip of the blade is situated in the right tonsil area (arrow).

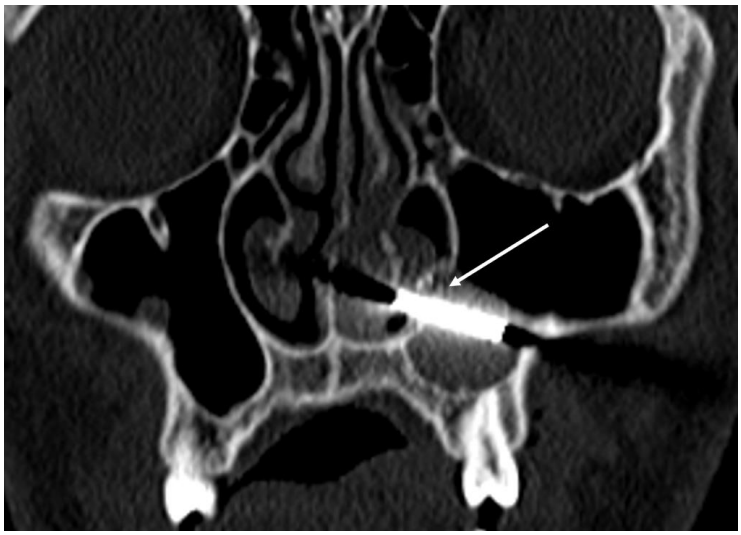


**Fig. 8. CT scan (bone window).** Coronal view. The blade crossing the left nasal wall of the left maxillary sinus (arrow).

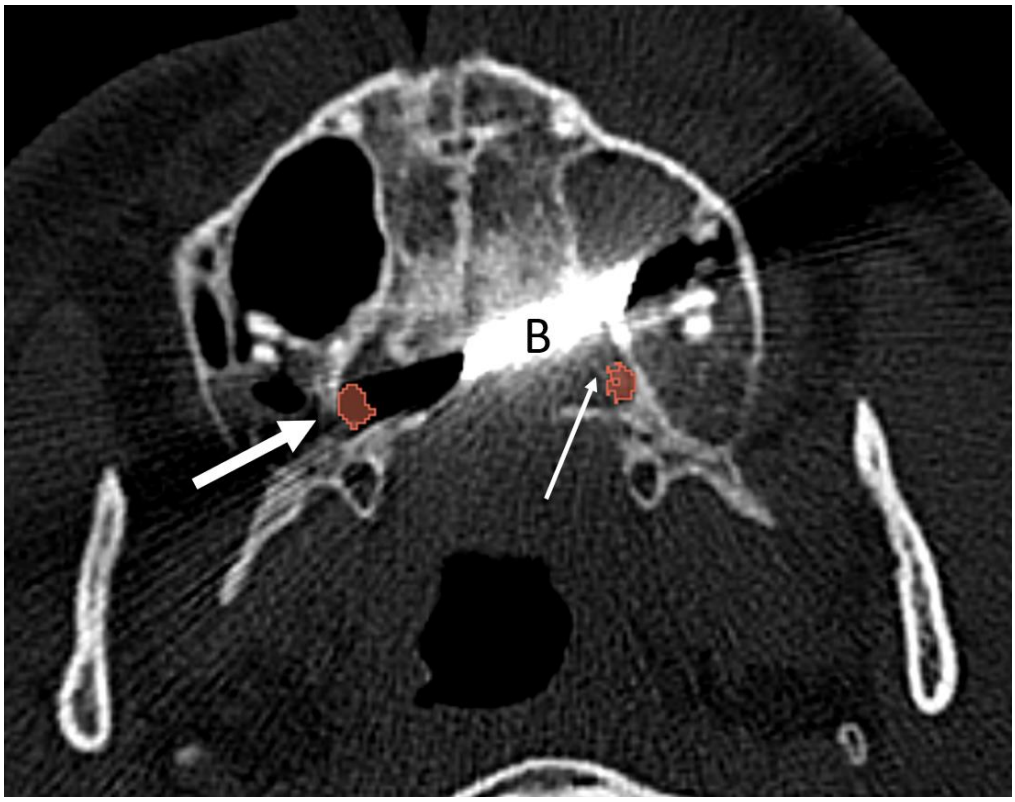



**Fig. 9. CT scan (bone window).** Axial view. The relationship between the blade (B) and the right and left descending palatine artery in the great palatine canal. Close relationship between the blade and the left descending palatine artery (thin arrow). Metallic artifact caused by the blade, and projecting on the right descending palatine artery (thick arrow). Reconstruction of the descending palatine arteries with 3DSlicer software (in red).

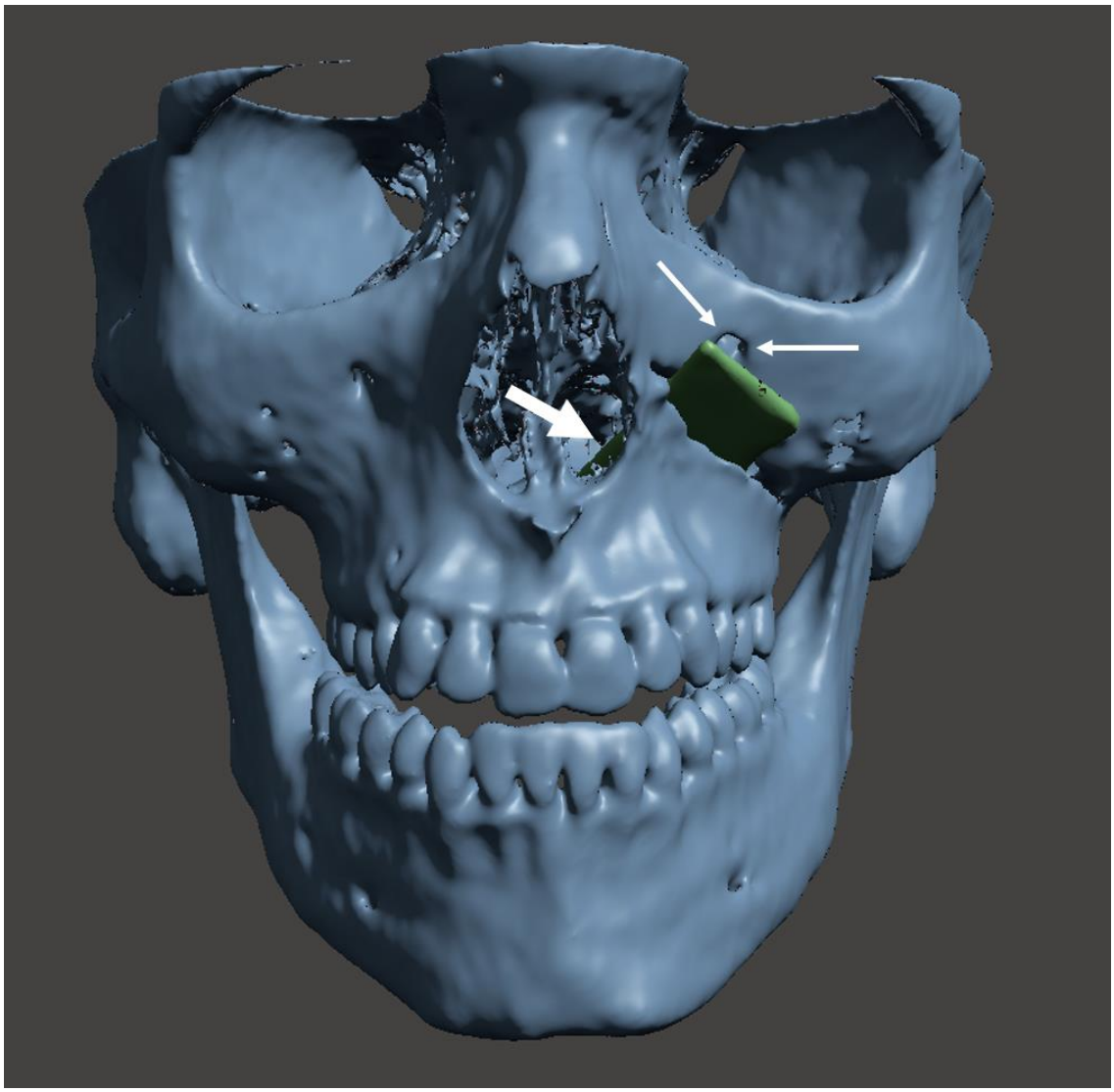


**Fig. 10. 3D CT reconstruction after segmentation of facial bones (blue), and of the blade (green).** Frontal view. Entering point of the blade is situated under the left infraorbital foramen (thin arrows). Blade inside the left nasal fossa (thick arrow). Segmentation performed with 3D Slicer. 3D reconstruction performed with Meshmixer software.

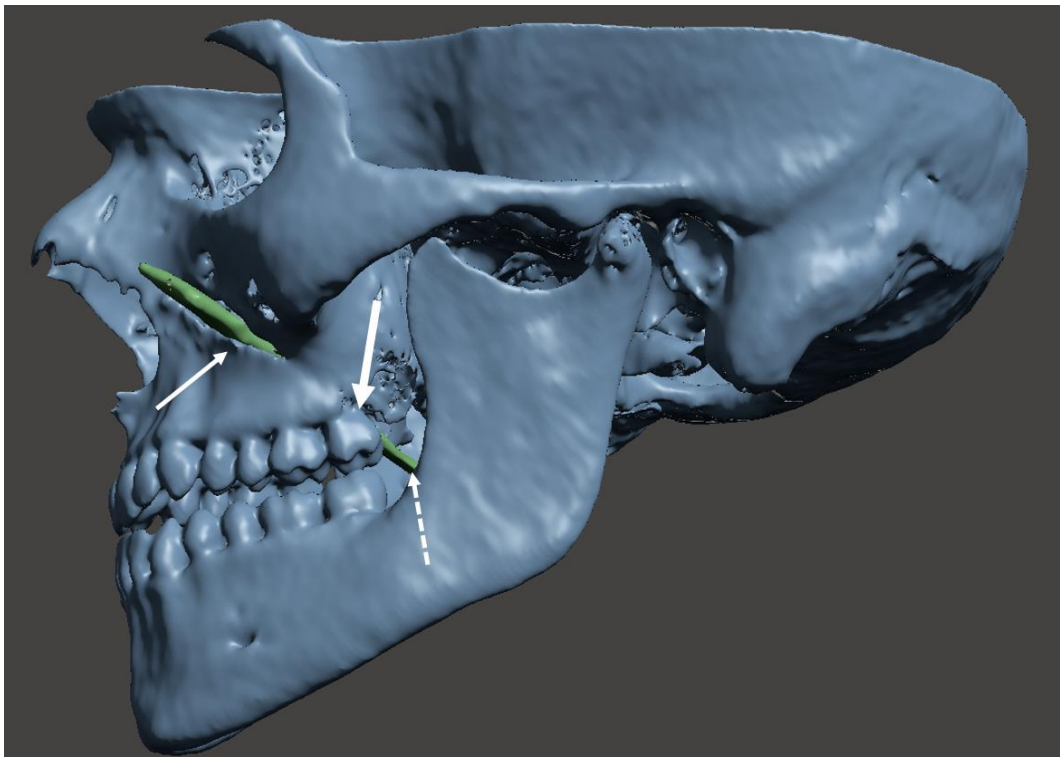


**Fig. 11. 3D CT reconstruction after segmentation of facial bones (blue), and of the blade (green).** Left lateral view. The blade is oriented diagonally to the oral cavity. The blade perforates the anterior wall of the left maxillary sinus (thin arrow), passes close to the tooth n°27 (thick arrow), and enters the posterior oral cavity (dashed arrow).

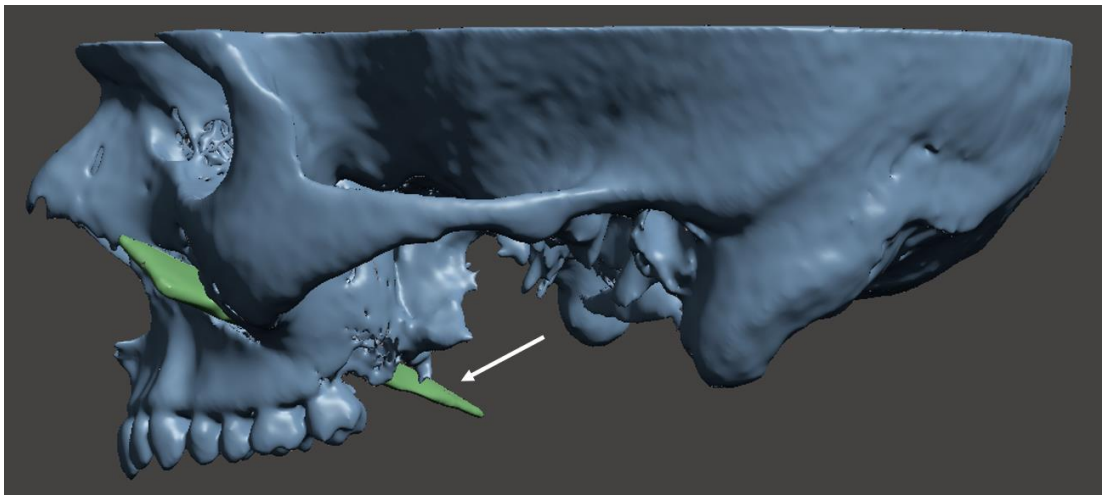


**Fig. 12. 3D CT reconstruction after segmentation of facial bones (blue), and of the blade (green).** Left lateral view without the mandible. Deep entering of the blade into the tonsil area (arrow).

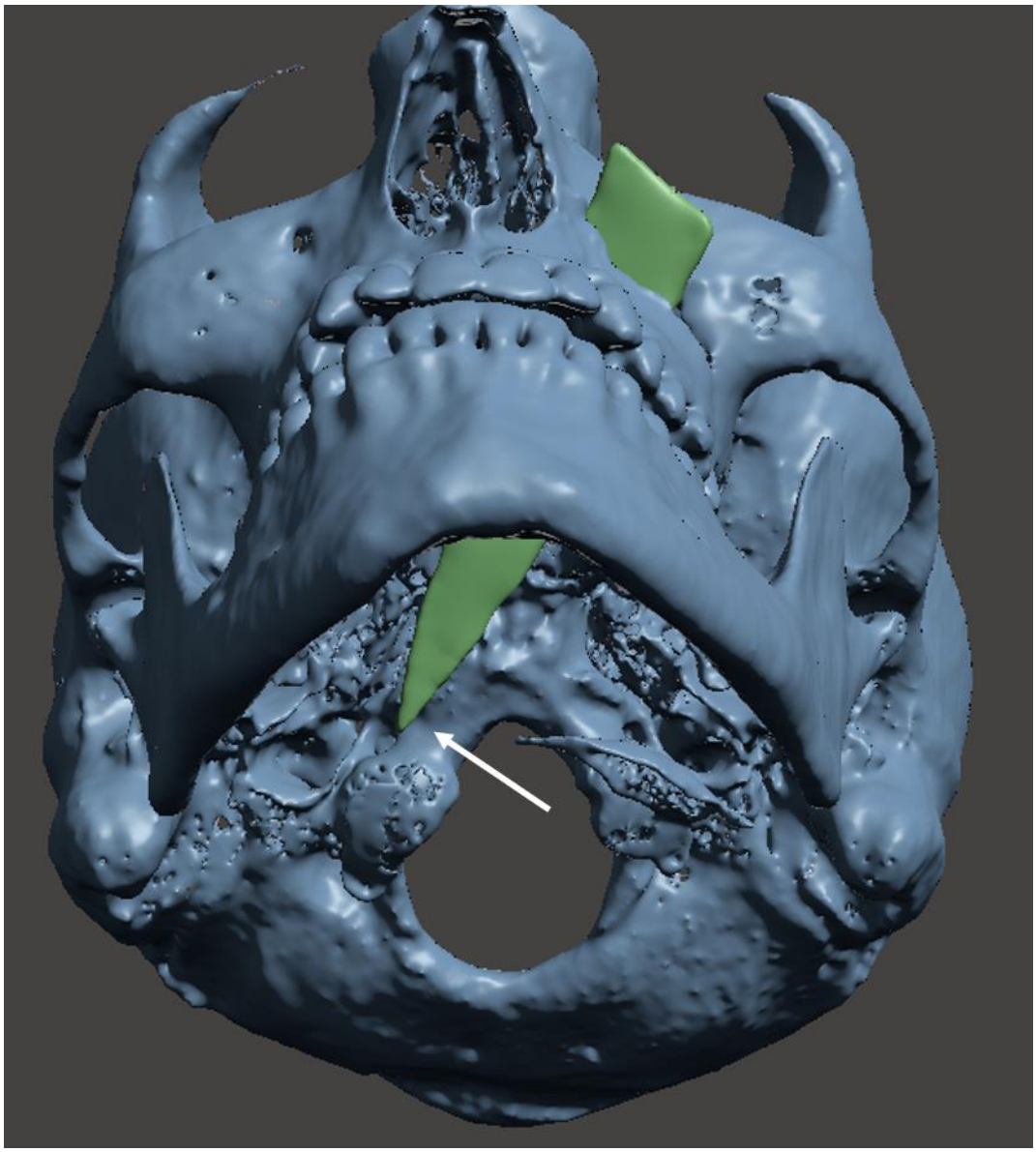


**Fig. 13. 3D CT reconstruction after segmentation of facial bones (blue), and of the blade (green).** Frontal, and inferior to superior view. The blade is crossing the midline, and with deep entering into the right posterior oral cavity and tonsil area (arrow).

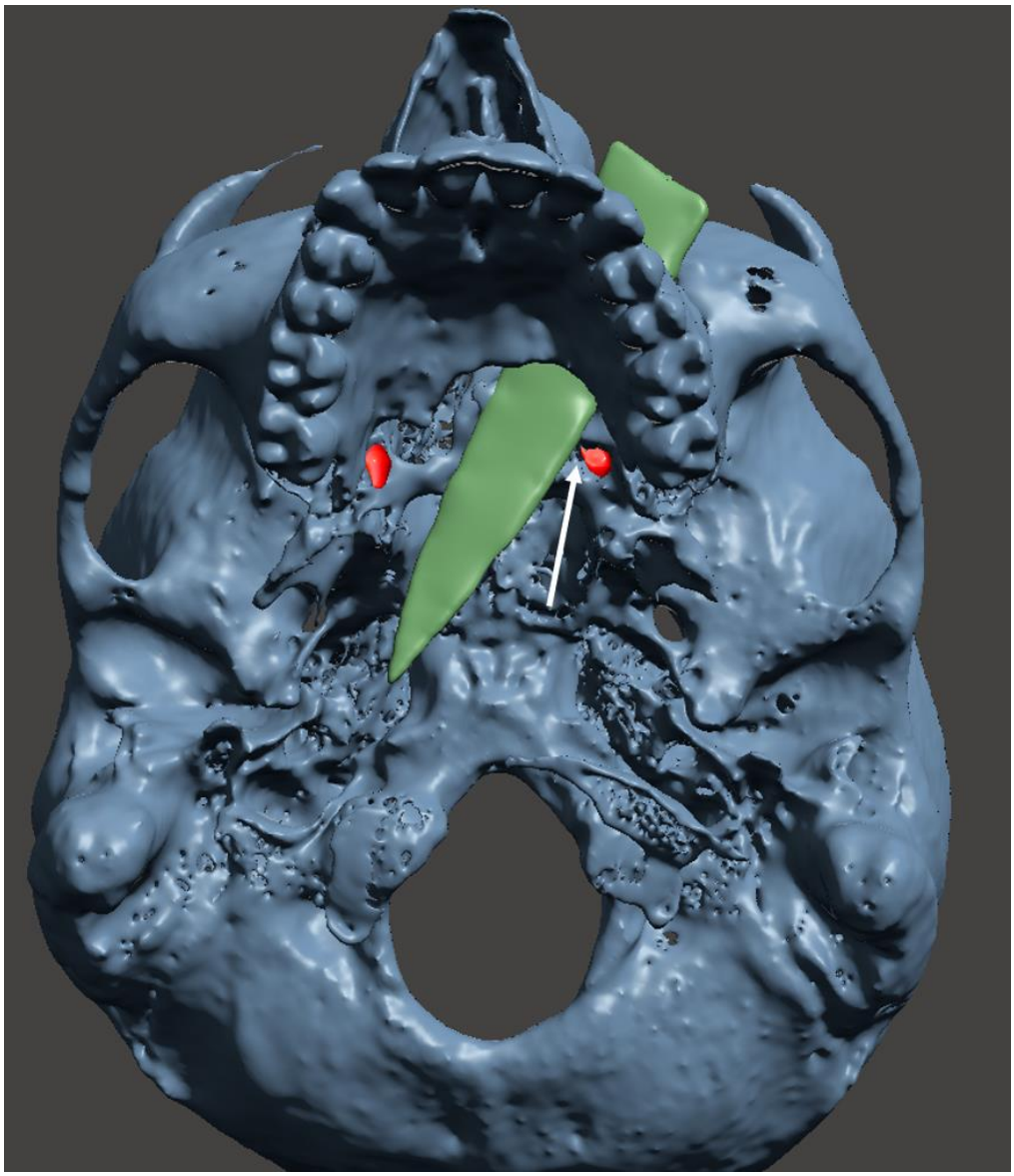


**Fig. 14. 3D CT reconstruction after segmentation of facial bones (blue), of the blade (green), and of descending palatine artery (red).** Inferior view of the skull. The blade is oriented from outside to inside (left to right), crosses the midline, penetrates the right tonsil area. The blade passes close to the left great palatine foramen (arrow).

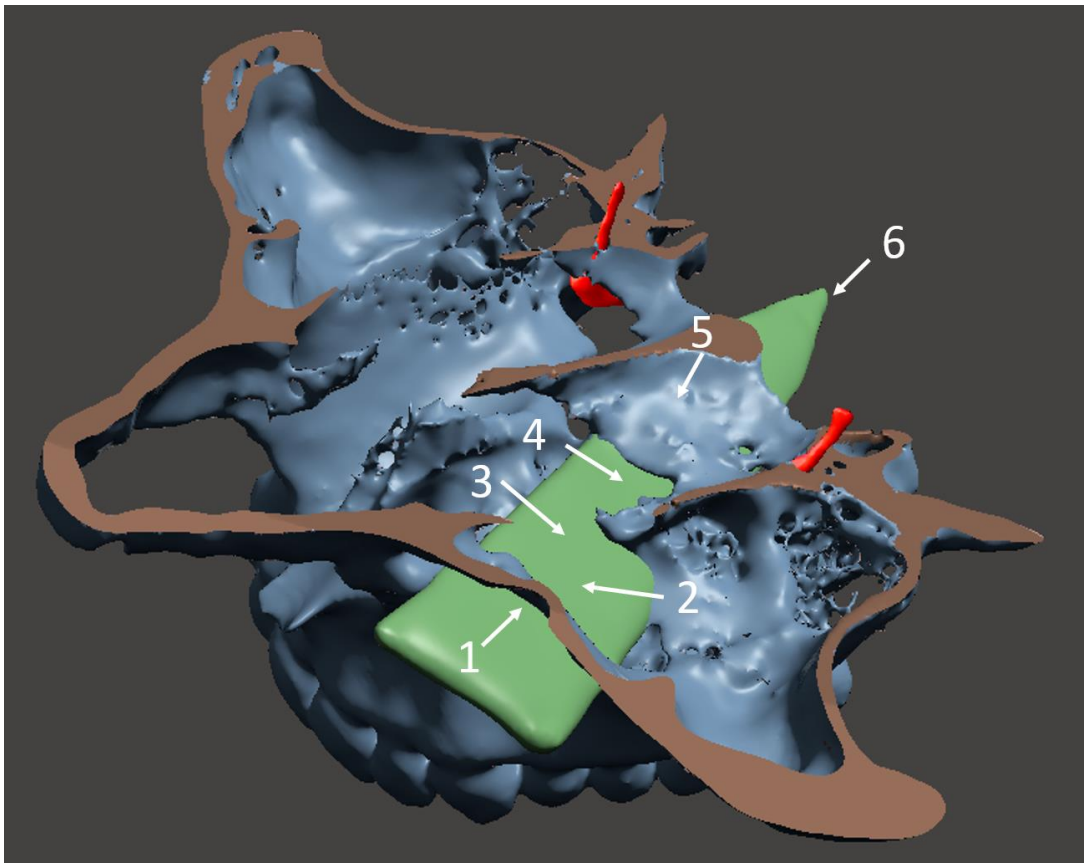



**Fig. 15. 3D CT reconstruction after segmentation of facial bones (blue), of the blade (green), and of descending palatine artery (red).** Upper left lateral view. Axial slicing of the 3D reconstruction showing the relationship between the blade and the anatomical landmarks. Blade entering the anterior wall of the left maxillary sinus (1), passes through the left maxillary sinus (2), passes through the nasal wall of the left maxillary sinus (3), enter the hard palate in the left nasal fossa (4), passes the midline under the palatine bone (5), and stops in the right tonsil area (6).

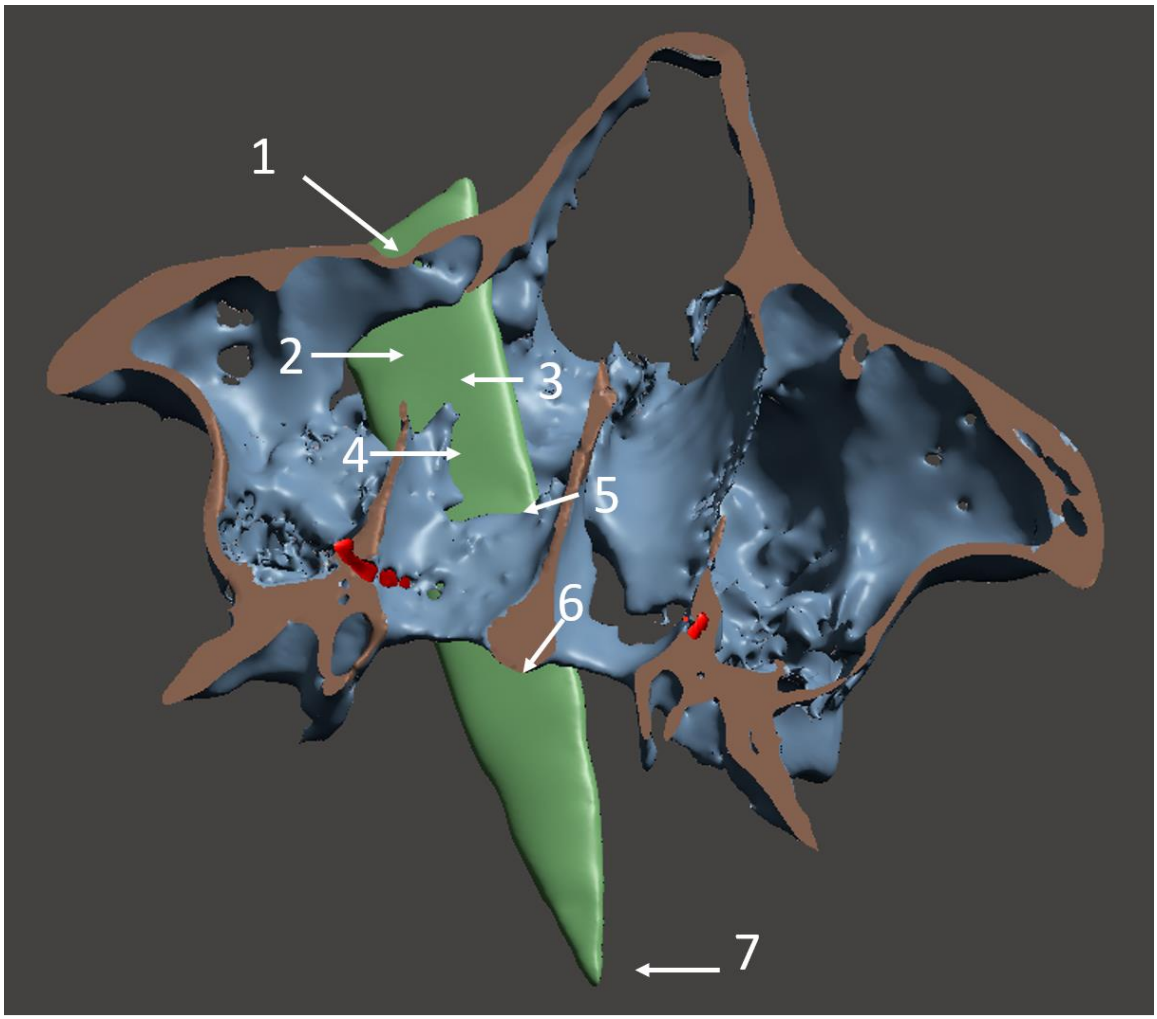



**Fig. 16. 3D CT reconstruction after segmentation of facial bones (blue), of the blade (green), and of descending palatine artery (red).** Upper view. Axial slicing of the 3D reconstruction showing the relationship between the blade and the anatomical landmarks. Blade entering the anterior wall of the left maxillary sinus (1), passes through the left maxillary sinus (2), passes through the nasal wall of the left maxillary sinus (3), enters the left nasal fossa (4), enters the hard palate in the left nasal fossa (5), passes the midline under the palatine bone (6), and stops deeply in the right tonsil area (7).

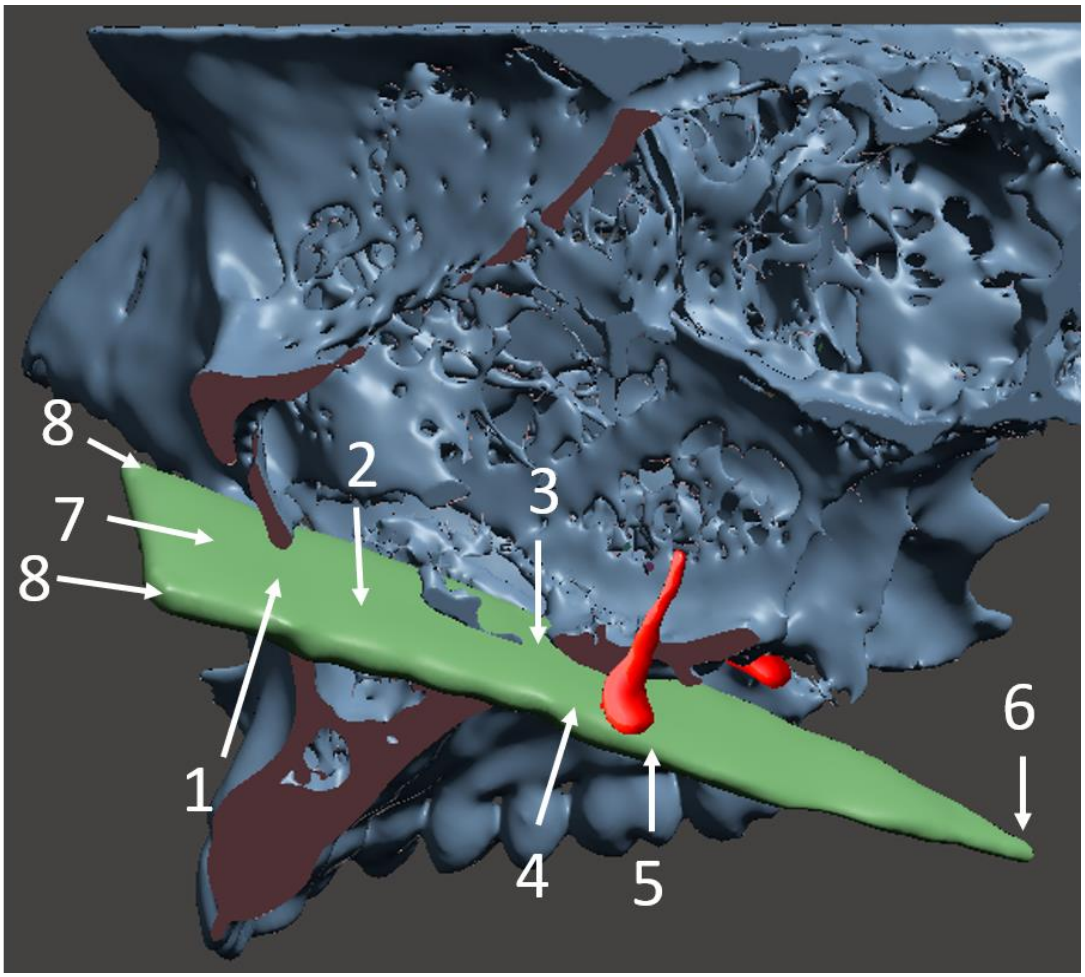
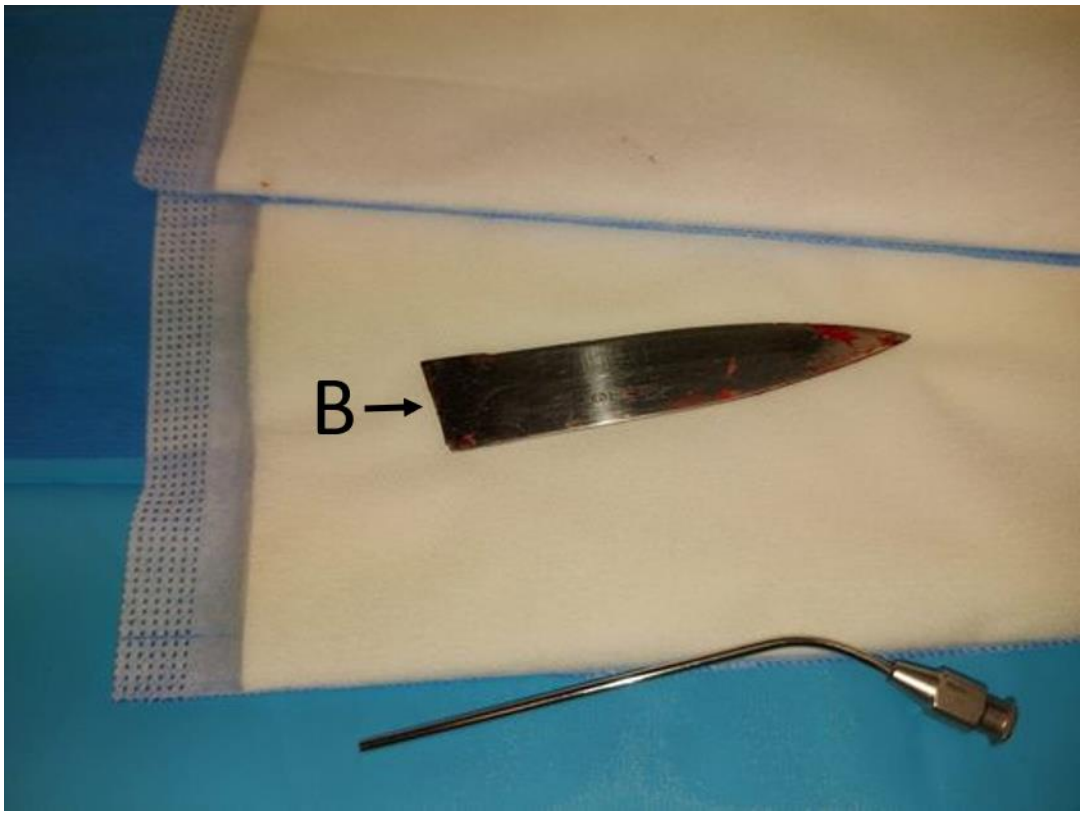



**Fig. 17. 3D CT reconstruction after segmentation of facial bones (blue), of the blade (green), and of descending palatine artery (red).** Left lateral view. Sagittal slicing of the 3D reconstruction showing the relationship between the blade and the anatomical landmarks. Blade entering the anterior wall of the left maxillary sinus (1), passes through the left maxillary sinus (2), enters the hard palate in the left nasal fossa (3), passes under the palatine bone (4), passes close to the left descending palatine artery (5), and stops deeply in the right tonsil area (6). Smooth surface of the blade (7). Lateral edges of the blade (8).

## Intervention

The removal of the retained blade was planned under general anesthesia with oro-tracheal intubation. Due to the presence of the tip of the blade in the tonsil area, we contacted the otolaryngologists in order to evaluate the presence of an injury in the right tonsil and, if necessary, the application of immediate surgical treatment.
Intraoral intubation was considered difficult due to the poor visualization. Moreover, as it was a contraindication of the mobilization of the head and neck, the intubation was performed with a classic GlideScope® guided induction for laryngeal visualization with minimal orofacial manipulation. This procedure took place under the direction of 3 anesthetists including 2 experienced supervisors.
The airway backup plan included an Eschmann introducer, and the final backup airway plan was the cricothyroidotomy, with the neck already prepared for the surgery. After disinfection and classical draping, the clinical examination of the tonsil area did not show any injury.
The retained blade was approached through the facial entry wound with medial and lateral enlargement of the facial entry wound followed by dissection, and reclination of the maxillary sinus periosteum. The blade protruded 1 cm from the anterior wall of the left maxillary sinus. Despite multiple attempts the blade remained in place due to the poor grip of surgical forceps on the metallic smooth surface of the blade. This lack of grip made impossible to remove the retained blade using only different kind of surgical forceps.
However, the removal of the retained blade was made possible by performing a ball burr osteotomy of the anterior wall of the left maxillary sinus around the blade, the grip with the forceps on the edges of the blade (Figure 17), and a movement of rotation of the blade along its main axis induced by the forceps. This approach allowed the mobilization of the blade and its gentle removal.
The removal caused minor bleeding that did not require any particular hemostatic procedure.
Afterwards, a simple closure in 2 planes was performed on the face, and by simple suture on the palate after disinfection and syringing of the wound with polyvidone-iodine solution.

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336 **Fig. 18. The blade (B) removed *in toto*, with dimensions of 8.4 x 2 cm.**

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**Fig. 19. Immediate post-operative situation.** Sutures of the entering area under the left orbit (arrow). Hematoma in the left lower eyelid. Minimal swelling of the left cheek. Right oral intubation.

The patient stayed one night in the hospital and received amoxicillin 500 mg 3 times per day for 5 days. The follow-up was performed at 5 days after surgery to remove the sutures. It revealed only the hypoesthesia of the left infraorbital nerve and a doubtful vitality test on teeth n°26 and n°27.

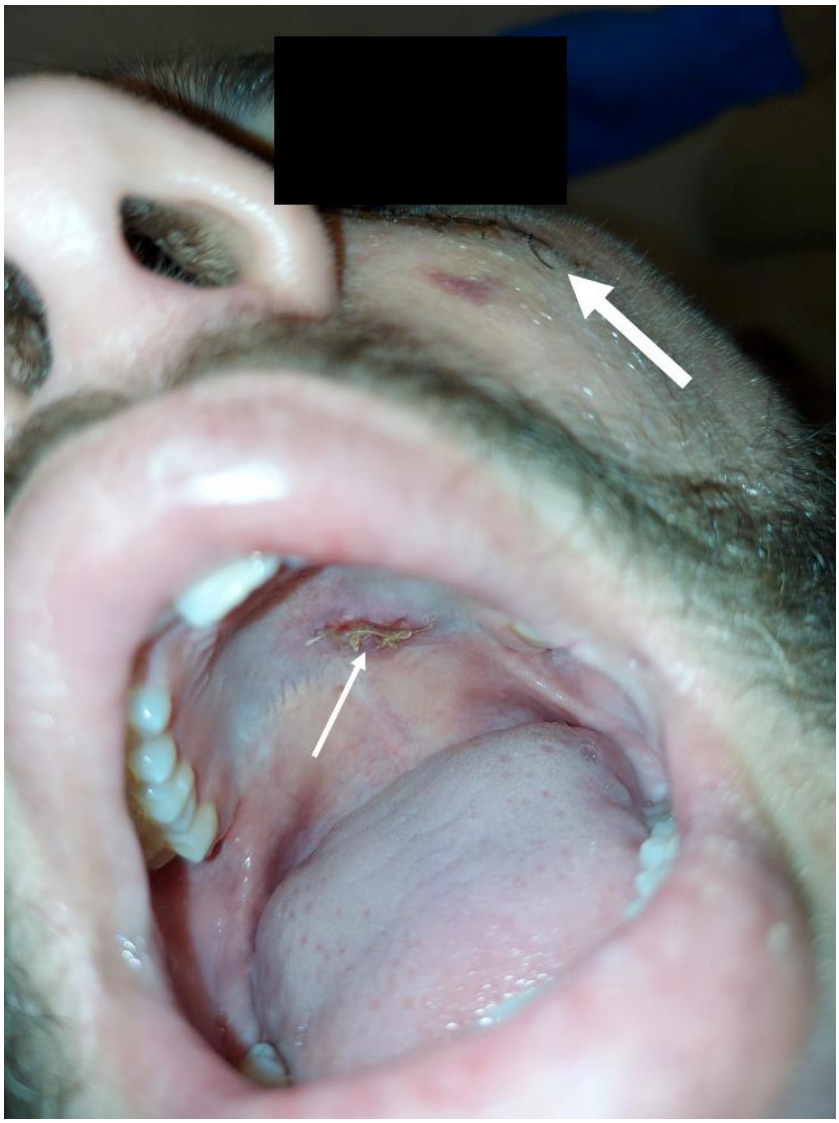

**Fig. 20. The follow-up at 5 days after surgery.** Healing of the entering area on the left cheek (thick arrow), healing of the left palatine wound (thin arrow).

**Fig. 21. The follow-up at 5 days after surgery.** Healing of the entering area on the left cheek (thick arrow). Glass hematoma around the lower rim of the left orbit.

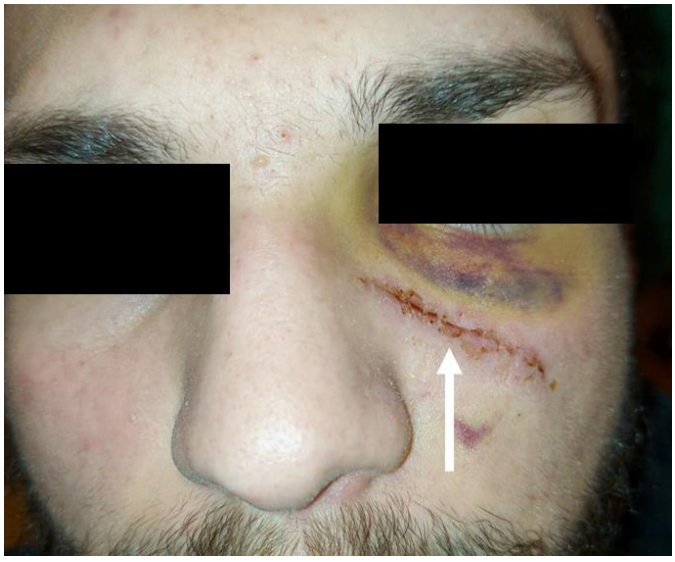

**Fig. 22. The follow-up at 5 days after surgery.** Healing of the entering area on the left cheek (thick arrow) after removal of the sutures. Glass-type hematoma around the lower rim of the left orbit.

**Fig. 23. The follow-up at 14 days after surgery.** Healing of the entering area on the left cheek (thick arrow).

At 3 months after surgery the patient had recovered most of the sensitivity of the left inferior orbital nerve, and presented with normal vitality tests on teeth n° 26 and n°27.

## Discussion

The face performs several functions in humans such as breathing, eating, seeing, hearing and communicating as well as socializing [41]. Because of the interdependence of its complex anatomical and functional structures, the management of the facial trauma involves an interdisciplinary approach, and can quickly engage the expertise of a multitude of medical and of surgical specialties such as maxillofacial surgeons, otolaryngologists, ophthalmologists, neurosurgeons, plastic surgeons, radiologists, interventional radiologists, anesthetists, emergency physicians, and intensivists. This situation leads up to complexify the management of facial trauma.

The spectacular aspect of injuries with impaction of the blade in the face as well as its rarity often led to concentrate on the management of the retained tool rather than on the initial resuscitation of the patient [42, 43]. However, the clinical examination must remain systematic and routine.

The ATLS® algorithm is recognized as the gold standard in the initial management of polytraumatized patients, and is instructed in more than 50 countries worldwide. Its simplicity and systematic approach have contributed greatly to improve the quality of care for trauma patients worldwide. It is estimated that the reduction of deaths caused by polytrauma is of 25-30% when a systematic and organized approach is used [44]. The ATLS is based on a two-step approach, primary and secondary.

During the primary investigation the first priority consists of stabilizing the patient. The care must be taken to secure the airway, treat active bleeding (especially of the carotid artery system), and exclude neurological or vision damage [45]. Nonetheless, penetrating maxillofacial injuries do not usually create major resuscitation problems [46]. However, immediate attention should be directed to the assessment and to the management of the airway and of the bleeding. The head and neck are the most vascular areas. Massive hemorrhage, tissue hematoma, compression of displaced tissue, airway secretion, and other complications can lead to shock [5]. Up to 1/3 of patients with maxillofacial trauma require emergency airway management, and the presence of blood, bone fragments, and loose teeth can make airway assessment and management difficult [47].

The particularity of stab wounds is the unpredictable component of the depth of penetration. It is therefore recommended that if the blade is still present in the wound at the time of evaluation, to leave it *in situ* until diagnostic (radiological) studies are performed, and the patient is in the operating room. It should be remembered that a foreign body provides some buffer for the damaged blood vessel, and often the removal of the foreign body results in massive bleeding [37, 48].

Ventilation of patients with affected structures of the middle third of the face can be complicated as it can be difficult to ensure an adequate mask seal, it can mobilize the blade, while positive pressure ventilation can aggravate subcutaneous emphysema and worsen the injury [49-52]. Similarly, the patient who has potentially swallowed blood should be considered non fasting, and may justify a crush induction procedure.

On the other hand, it is essential to prevent coughing and any blade and/or head movement during intubation to avoid injury to the vascular axes (internal carotid artery).

Video laryngoscopy in the hands of an experienced user (able to manipulate the endotracheal tube based on the video view rather than on a direct view) can mitigate the effects of difficult anatomy, and maintain minimal mobility for the head and neck while allowing adequate supervision by other operators [53]. The personnel and equipment required for emergency crycotomy should be readily available and accessible [50-52]. At the same time, the diverse nature of penetrating injuries to the face and neck impedes a single method of airway management [53].

Once the patient is stabilized and the airway is secured, the long-term treatment goals are to restore facial shape and function. It is the role of the secondary investigation to get an idea of the severity of the trauma by identifying the anatomical structures implicated or potentially implicated by the blade. As a reminder, the depth of penetration remains unpredictable. For this purpose, computed tomography (CT) is largely accepted in the evaluation of retained blades [54]. However, metallic objects such as blades cause marked beam hardening artifacts, which can lead to significant diagnostic problems depending on the case [54; 55]. Although small metallic objects such as bullet fragments have been shown to have a rather low impact in the lower extremities, this may not be the case in the maxillofacial region due to the complex bony anatomy and due to the small caliber of the external carotid artery branches [56]. The presence of a large metallic object such as a knife blade *in situ* would create a significant beam hardening artifact that would complicate reliable interpretation of vessel morphology or make its interpretation impossible [1].

However, advances in cone-beam CT should lead to a reduction in beam hardening artifacts due to metallic objects, and currently catheter angiography and cone-beam CT can be combined [57]. In the future, these patients will probably be better examined by cone beam CT angiography [1].

In case of uncertainty or close relationship of the blade with vascular structures it is recommended to perform a diagnostic or therapeutic angiography. If the path of the knife is clear of the base of the skull and of the main vessels, the angiography is not mandatory [1, 6, 31, 58].

The consequences of penetrating trauma depend of the affected anatomical structures, of the extent of penetration, of the impact and direction of the offending foreign body, and of the strength of the tissue affected by the trauma [5, 59-62]. In general, stab wounds are known to have a low mortality [39]. This can be attributed to the limited energy dissipation (along the blade), which leaves the adjacent tissues intact, and to the low velocity of the trauma. In a study at a major trauma center in London, out of 938 patients, four patients died, resulting in a case fatality rate of 0.53% [26]. The most dangerous site for stabbing is the chest [36, 63, 64]. However, these results are to be put in balance with the fact that the study does not distinguish between incised and penetrating knife wounds and that the study describes cases that actually arrived at the hospital [26]. One important point is that a knife can be very deadly in the hands of an experienced person [36, 63, 64]. However, this low fatality

of facial penetrating trauma has been noted by some authors [1, 65], and highlights the protective function of the viscerocranium, which through its bony structures acts as a cushioning zone that absorbs the energy of trauma, and protects the intracranial structures [34]. Moreover, in the case of Jael's syndrome, when it affects the face, its laterality is in two thirds cases on the left side. This corresponds to the fact that the majority of the population is right-handed, so the majority of attackers are right-handed, and it is easier for them to hit the left side of the victim [36, 66, 67].

During an attack with a movement over the shoulder, the axis is often superior-inferior, and latero-medial (orientation found in the illustration of the "wounded man" (Figure 1, and in our present case). This orientation has the advantage of being an axis that is away from the large vessels [6].

The treatment focuses on the removal of the retained blade if it is not contraindicated. This procedure requires a thorough understanding of facial anatomy [68]. The surgical approach includes either simple removal, wound exploration and removal, or open surgery and removal defined as follows [69]:

- Simple removal: the retained blade was removed along its entry line without additional surgical intervention.
- Wound exploration and removal: the entry wound was surgically extended and the retained blade was removed under direct vision.
- Open surgery and extraction: retained blades involving deeper structures and those not visible from the outside required dissection of the entry wound, laparotomy, thoracotomy or even osteotomy followed by removal under direct vision.

Computer Assisted Surgery (CAS) can help us with diagnosis, surgical planning and treatment to decrease the incidence of complications in delicate or complex cases [70, 71]. The choice of removal type is of course case-dependent, and should allow for the least traumatic removal, while removing the foreign body, and allowing for management of hemostasis [1, 3, 36, 37, 72]. However, the removal of a knife retained in the bone can be difficult (the biomechanical elements underlying are illustrated on Figure 24). This particularity has already been highlighted in the course of history where it was not uncommon to have to go over it several times before succeeding in removing the retained blade [73]. A good illustration is the case of François de Lorraine, Duke of Guise of whom Ambroise Paré (French surgeon) attending the siege of Boulogne in 1544, succeeded in removing a spearhead retained in the face of the Duke but had to use a farrier's pliers, and applied his foot on the head of the Duke in order to remove the blade from the face of the latter. This episode earned afterwards the Duke of Guise the nickname of “le balafré” (the scarred one) [73].

From a global standpoint, the force required to cause an injury with a knife are grouped into mild, moderate and severe [74]. Light force would generally be associated with penetration of skin and soft tissue, while moderate force would be required to penetrate cartilage or rib bone. Severe force, on the other hand, would be typical of a knife striking a dense bone such as the spine, and sustaining visible damage to the blade [74]. For a knife to pass through the cartilage, it has been reported that it may require 140 Newton and for the sternum 200 Newton [75]. In a study to determine the force developed during a knife attack with an over-the-

shoulder pronated gesture, it was found that volunteers could generate up to 2000 Newton of force along the long axis of a blade on impact, and reach impact speeds of 10 to 18 m/s [76]. Note that none of the volunteers were in a state of fear, rage or excitement, which could tend to increase physical performance.

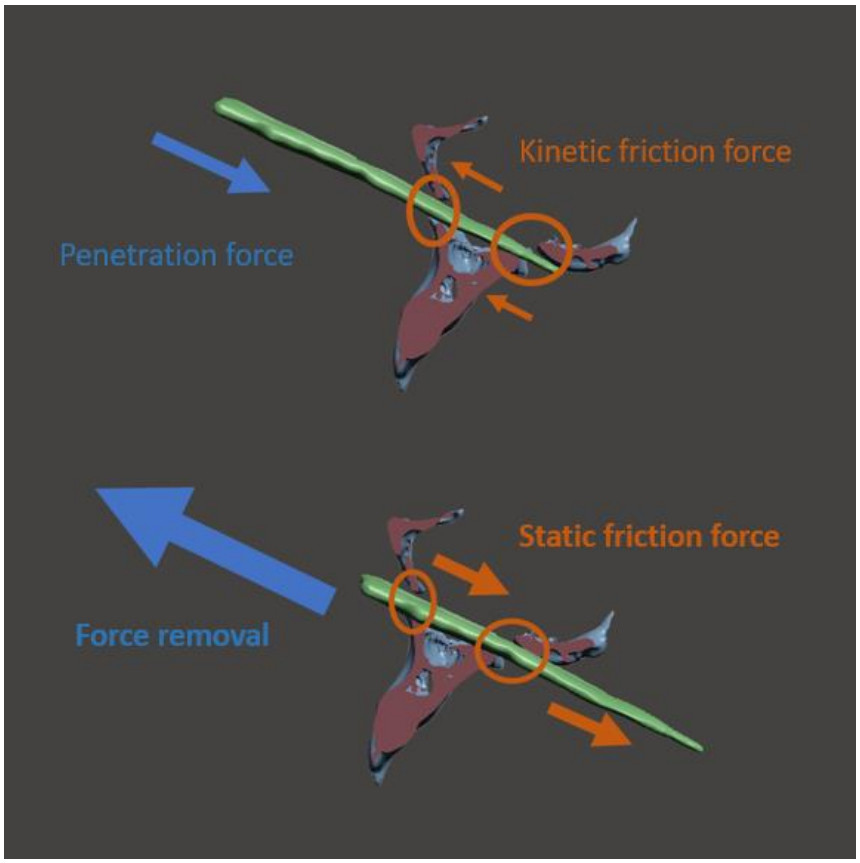


**Fig. 24. 3D CT reconstruction of the bone structures and of the blade (green).** Since the knife blade has a high inertia during a knife attack, its friction coefficient (metal/bone) is kinetic and therefore lower than the static friction coefficient (metal/bone) that is found during the removal. If the bone structures have not fractured (which is often the case for a pure sharp force) the force required to withdraw the blade may be greater than the force developed during the attack.

One tip is to use large forceps and tap the clamp holding the knife with a surgical hammer to minimize iatrogenic damage [77, 78]. However, this technique is not

always applicable because a common characteristic of knife attacks is that the knife is often twisted or broken after the attack [18]. This is because knives are rarely inserted into the body and removed at exactly the same angle (unless the victim is incapacitated at the time of the attack) https://www.forensicmed.co.uk/wounds/sharp-force-trauma/stab-wounds/ [79]. This feature has been noted by several authors especially with cheap kitchen knives that can easily break with minimal force, and when such a knife tip hits the bone, the tip can break, and remain embedded in the bone [76, 80]. This characteristic is more pronounced with the longer blade. The *"ideal" weapon is, in fact, a short knife with a thin blade, with a rigid blade of about 7 cm long"* [80]. This tendency to break or twist can complicate the removal of the knife due to the lack of contact surface for forceps and due to the modification of the removal axis.

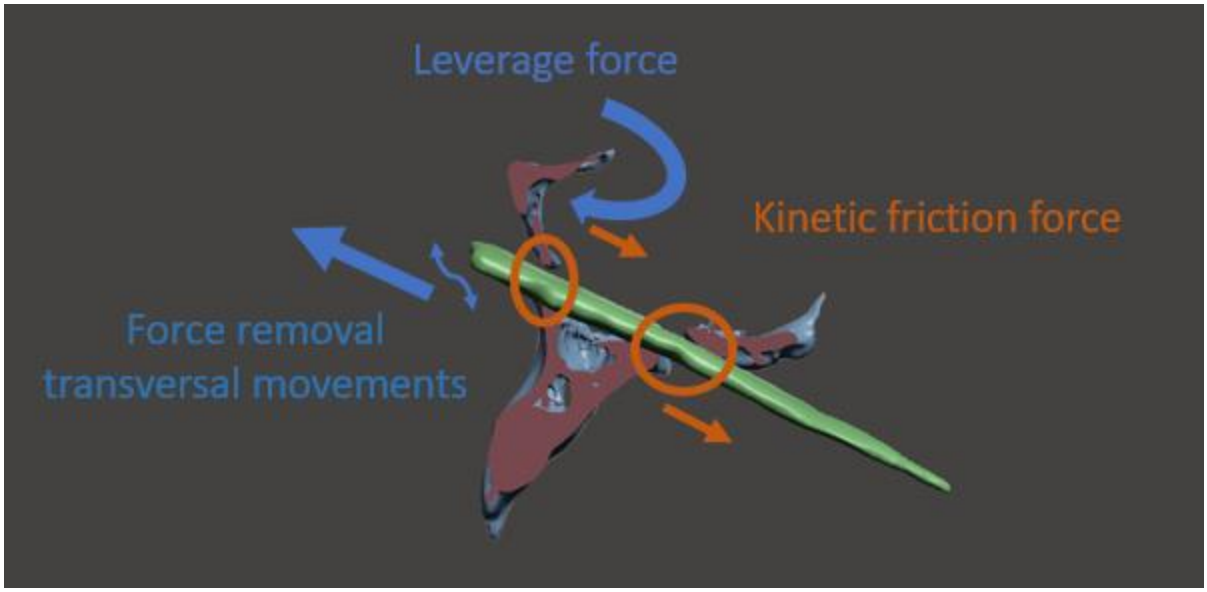


**Fig. 25. 3D CT reconstruction of the bone structures and of the blade (green).** In the present case the removal of the knife was complicated by the lack of grip of forceps on the contact surface of the blade. We had to perform an osteotomy of the anterior wall of the left maxillary sinus in order to free the exit axis. We performed the transversal movements and rotation movements along the main axis of the blade to initiate the removal of the blade.

Our procedure (Figure 25) allowed the realization of leverage force through a metallic instrument followed by a mobilization of the blade in the transverse direction. These transverse movements are a technique commonly used in oral and bone surgery when it is necessary to recover an osteotome blocked in the bone. This

technique allows to decrease the coefficient of friction metal/bone by transforming it into a kinetic coefficient.

Moreover, when faced with a clean-edged wound (typical of stabbing attacks), it is necessary to suspect that blade fragments are present and should require imaging to allow early diagnosis of retained blades [37]. Indeed, late discovery of fragments is not unusual in a series of 33 patients and occurred in six patients (18%), four of whom presented with subcutaneous swelling, and two with wound abscesses [69]. As the knife attacks only last a few seconds, the patient may not be aware of the attack, and the history may be missing [81, 82]. Subsequently, the retained blade may be minimally reactive, and remain in the tissue for years without damaging adjacent structures. However, they can also produce chronic inflammatory reactions, making them a source of acute/chronic infection, as well as secondary bleeding caused by movement of the blade during modifications in body positions [83]. When a foreign body has been embedded in the tissue for a long period of time, the entry tract becomes obliterated, making it difficult to locate the object. The foreign body is surrounded by a thick layer of fibrous tissue, which makes the removal even more difficult [84]. The longer the foreign body retention time, the more tissue edema will occur. It is therefore recommended to remove the retained blade as soon as possible within 24 hours of the diagnosis [84]. The absolute indications for removal of a foreign body in the facial region are: organic origin, freely palpated object, position anterior to the orbit, with a high toxicity, in intra-articular position, with presence of infection or mechanical and functional impairment [36]. Other indications include neurological impairment and compromised aesthetics [85].

Contraindications to inorganic origin include location posterior to the orbit, proximal to vital structures, lack of imaging studies, risk of iatrogenic injury, absence of symptoms or unclear location [36]. However, Grobbelaar et al., [6] showed no adverse effects after simple removal of the retained blades in 11 patients. Similar uneventful intraoperative and postoperative results were observed by Shadid et al. [86]. Bullock et al., [87] reported a patient with acute carotid-cavernous fistula due to stabbing. However, before an intervention the question of the benefit/risk balance of the removal of the blade must be asked. Also, if conservative management has been chosen, clinical and radiological support is necessary to prevent and treat possible future complications.

The aesthetic potential of the wound depends on the orientation of the wound in relation to the line of tension of the facial skin. A parallel incision will open less than a perpendicular one, and heal with a thin linear scar whereas a transverse incision is likely to result in an irregular distribution of local tension leading to an unsightly scar [74]. The healing is also related to the type of sharp/semi-sharp weapon (injuries resulting from a combination of sharp and blunt force). Sharp weapons such as knives tend to heal better than semi-sharp weapons such as broken bottles, axes, machetes which traumatize the edges and subcutaneous tissue more, and can leave large scars [88].

Prescription of preoperative and postoperative antibiotics as well as postoperative tetanus prophylaxis are recommended [3, 37, 89]. The prevention of infection is

important especially in the "triangle of death" area of the face drained by the angular vein that drains into the cavernous sinus.

It is interesting to see that our case is close to several characteristics already mentioned by Jett et al., [90] describing the characteristics of the typical victim. The typical patient was a male, from an ethnic minority, between 15 and 35 years of age, who arrived at the emergency room between 9:00 pm and 2:00 am on a Friday or Saturday night. He was often a drug addict, and the injury resulted from family conflicts. Another study showed that the victim and perpetrator knew each other 86% of the time [19]. The majority of incidents are spontaneous, occur in the home and in public, and use a sharp weapon of convenience, usually a kitchen knife probably due to its wide availability [11, 21].

In summary, in cases of Jael's syndrome effective coordination, communication, and teamwork of emergency medicine, anesthesia, radiology, surgery, and removal services must be carefully implemented.

However, despite the fact that several attempts have been made to establish algorithms and classify penetrating craniofacial injuries, the variety of cases reported argues for an individualized approach.

- **Acknowledgements**: none
- **Funding sources statement**: this study does not receive any funding
- **Competing interests**: Prof R Olszewski is the Editor-in-Chief of NEMESIS. Dr J Massaad declares non conflict of interest.
- **Ethical approval**: there was no need of ethical committee approval for this case report.
- **Informed consent**: a written informed consent was obtained from the mother of the patient. All images were anonymized and no private data were provided allowing the patient's identification.

**Authors contribution:**

| Author | Contributor role |
|---|---|
| Massaad Jean | Conceptualization, Investigation, Methodology, Data curation, Resources, Validation, Writing original draft preparation, Writing review and editing |
| Olszewski Raphael | Conceptualization, Investigation, Validation, Writing original draft preparation, Supervision, Writing review and editing |

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