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Review

Reflections on a patient-centered approach to treatment of blow-out fractures: Why the wisdom of the pastmust guide our decision-making

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Summary The management of blow-out orbital fractures (BOFs) continues to be controversial and regularly questioned. In recent years, treatment decision-making has shifted from a clinically dominated emphasis to a more objective data-based approach. This has come about through the refinement of imaging technologies that can more precisely define the fracture itself. Decision-making is now mainly driven by computed tomography (CT) parameters among which the fracture's size is by far the most often used.

The variability in a patient's clinical presentation and outcomes for similar types of BOFs raises serious doubts about the pertinence of applying standardized guidelines based on quantitative data for the treatment of individual patients. An approach that fails to include patient variability and relies too heavily on average objective results with an emphasis on the application of quantitative rather than qualitative methods can lead to poor patient outcomes.

A review of the knowledge accumulated over the many years of treatment of BOFs has demonstrated that despite the exceptional imaging-based technologies available, clinical acumen remains the most sophisticated decision-assistive tool. Thus, the treatment of BOFs must be regarded as a patient rather than merely a geometrical imaging issue. Imaging then becomes a

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valuable diagnostic rather than a final decision-making tool. This more conservative approach leads to a substantial decrease in indications for surgical repair.

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Introduction

The management of blow-out orbital fractures (BOFs) is complex and continues to be fraught with controversy.[1-9] The uncertainty hovering around the optimal management of such fractures mirrors an incomplete understanding of how individual clinical behavior interacts with the complex pathogenesis of such multifaceted entities. Apart from a few exceptions (e.g., trapdoor fractures, retrobulbar hematoma, hypoglobus or enophthalmos resulting in disfiguring facial asymmetry), the vast majority of BOFs are confined to atherapeutic “penumbra”, where there is no ideal treatment that is agreed upon by the clinical community.[1-9] Proof of this uncomfortable and ambivalent situation is provided by the increasing number of publications proposing ideal decision-making guidelines, based mainly upon the imaging parameters that we have been witnessing in recent years.[1-5] In this regard, this fervid scientific activity has probably raised more questions than answers, thus incentivizing the actual dissonant situation.

How has this intricate situation come about?

Traumatic enophthalmos: The beginning of the saga

In the 1880s, several authors reported on a new form of enophthalmos that occurred following orbital trauma. The term “traumatic” was used by Lang to contrast this form to “symptomatic” enophthalmos, which until then was the only form known.[10] In 1889, Lang was the first to suggest that fractures of the orbital wall could lead to the development of enophthalmos following the enlargement of the orbital cavity. He also suspected that the displacement of orbital fat through the fracture could result in a limitation of the eye’s motility.[10]

In 1918, Lagrange gave an extraordinary description of both the pathogenesis and the management of orbital fractures that occurred from war trauma.[11] With increased reliance upon X-ray, in 1943 Pfeiffer provided a detailed description of the possible mechanisms of what he called internal orbital fractures, which occurred without the involvement of the orbital rim, as well as the geometrical orbital changes favoring the development of the enophthalmos.[12] Curiously, he reported that most of the patients with enophthalmos were unaware of the deformity and thus did not require any treatment. Although Pfeiffer acknowledged the occurrence of the motility disorders and the diplopia, he failed in relating them to the prolapsed orbital tissues. Regarding management, it is interesting to point out that he considered only patients with fractures that caused annoying enophthalmos and/or diplopia to be eligible for surgery.

Blow-out fractures: The first intuitive description before the experimental consecration

King was the first to detail the downward bony displacement characteristic of BOFs and also the first to hypothesize that the forces transmitted through the globe to the floor were responsible for the orbital floor disruption.[13] He thus paved the way for the future hydraulic theory of blow-out fractures, which was definitively solidified 13 years later by the experimental work of Smith and Regan who failed to acknowledge his intuitive hypothesis. Moreover, King emphasized that (a) the diplopia rather than the enophthalmos is the dominant sequelae responsible for the permanent disability, (b) the intrinsic muscular injury cicatrization is involved in the occurrence of the diplopia rather than to a true muscular entrapment, (c) the diplopia is more related to a muscular imbalance rather than to a misalignment of the visual axis of the affected eyeball and (d) orthoptic exercises could relieve the diplopia.[13]

In 1950, Converse and Smith confirmed King's findings concerning the muscular imbalance in the occurrence of diplopia and highlighted that there was no characteristic pattern of diplopia and that the variability was related to the amount of intraorbital tissue damage and displacement within the maxillary sinus.[14]

The turning point: The "discovery" of blow-out fractures and the beginning of preventive surgery

The year 1957 was a hallmark for BOFs with regard to the description of their mechanism and management. First, Smith and Regan coined the term "blow-out" in their original article to indicate internal fractures of the floor and medial wall following a sudden displacement of the orbital contents leading to an increase in intraorbital pressure.[15] The "hydraulic theory" was thus born. The restriction in ocular elevation and depression was explained by the herniation of the inferior rectus and oblique muscles as well as the surrounding intraorbital tissues. They emphasized the difficulty in early diagnosis and advocated early surgical treatment to prevent complications (diplopia and enophthalmos).[15] In 1957, three main papers strongly supported the concept of early "exploratory" preventive surgery of all depressed blow-out fractures regardless of the presence of diplopia.[16-18] This surprising and invasive approach was dictated by the assumption that (a) unless surgery was performed within the first few weeks after trauma, the patient would suffer persistent diplopia and disfiguring enophthalmos, (b) the extent of injury beyond which spontaneous recovery would be impossible is difficult to determine and (c) considerable force would be necessary to replace the orbital contents in delayed surgical repair.

The tide started to turn…

In 1964, Bowers was the first to question the plausibility of "preventive surgery" in the management of BOFs.[19] He emphasized that the decision for surgery should be dictated entirely by the clinical signs, thus suggesting a more prudent and conservative approach in cases with no diplopia, enophthalmos or restriction of gaze. In 1971, Emery et al. found that roughly half their patients had persistent diplopia despite the surgical treatment and found no significant difference in the incidence of enophthalmos between surgical and non-surgical groups.[20] Although they suggested surgery for extensive BOFs to avoid enophthalmos, they nevertheless raised the question, "Is one justified in submitting all asymptomatic patients to surgery to prevent the possible occurrence of a cosmetic defect in approximately 20% of them?" All of these results started to undermine the "gut feeling" belief that surgery was the panacea for the management of all BOFs.

The natural history of non-treated BOFs finally revealed: A new insight into the clinical sequelae

Another year of paramount importance was 1974. Dulley and Fells were the first to give empirical clinico-radiological criteria for surgery (diplopia not resolving in the early days after injury, large herniation of orbital tissue, incarceration of tissue with resulting globe retraction and increased applanation tension on attempted up gaze and enophthalmos greater than 3 mm).[21] They were alsothe first to propose the rule of a "waiting period" of 14 days beyond which cases with persistent diplopia should undergo surgery.[21] This plan was based on their findings showing that late orbital repair of BOFs (beyond 14 days) had a high complication rate of both limited ocular movements and enophthalmos. This approach was defended by Greenwald et al., who emphasized the risk of complications related to the scarring of the orbital tissue beyond 2 weeks.[22] Putterman et al. were the first to report on the oculomotor assessment in patients with BOF that were managed by an observational approach for 4-6 months.[23] They assumed that the motility disorders were more related to the edema and the prolapsed orbital tissues than to a trapped inferior rectus muscle.[23] Moreover, they were also the first to define the bothersome diplopia as double vision occurring within 15° of the primary gaze and to recognize that only diplopia on down-gaze interfering with such activities as reading and walking should be considered for surgical correction.[23] Only 4% of patients had a bothersome diplopia and in all but one patient, the enophthalmos was found to be less than 3 mm.[23] As previously observed by Pfeiffer, the patients did not report any cosmetic complaints about their appearance and thus did not ask for surgical correction. They concluded that enophthalmos of 3 mm or less was usually cosmetically acceptable and did not require surgical treatment. The authors explained that resolution of the edema, absorption of blood, and stretching of the prolapsed fibrous fat by ocular exercises with movement in extreme upward and horizontal gaze were probably responsible for the relief of the symptoms after 4 months or longer.[23]

While until then, comminuted BOFs with prolapsed orbital contents within the maxillary sinus were associated with a high risk of motility problems and/or enophthalmos, Libsohn et al., in 1976, reported on the high incidence of both diplopia and enophthalmos in BOFs with floor comminution without prolapse.[24] Moreover, they demonstrated that the patients without diplopia in the primary gaze could be conservatively managed. By contrast, they showed that 20% of surgically treated patients, among which half had a diplopia in the primary gaze, developed persistent late diplopia. These findings highlighted the importance of diplopia in the primary gaze as a potential predictor of a bad outcome over the long term whether surgically or conservatively managed.[24] In 1977, Helveston reinforced the previous points by emphasizing that the restricted motility alone did not constitute a valid reason for early surgical intervention in BOFs and that attention should rather be paid to diplopia in the primary vison.[25] He also stressed that persistent diplopia after BOFs with or without surgery is related to nerve or muscular impairment rather than bony fixation. Based on this statement, late diplopia should be addressed as a muscular problem and thus treated either by the use of a prism on the lens or extraocular muscle surgery and not by a repositioning of the scarred orbital tissues.[25]Consequently, the idea that diplopia in the primary gaze and/or in daily activity constitutes the primary indication for surgery began to gain ground in the scientific community.[25,26]

Detailing orbital connective tissue: Openness to new perspectives beyond mere geometrical thinking

Koornneef demonstrated, by means of an anatomo-histological study, that the extra-ocular muscles were interconnected via an intricate network of connective tissue septa.[27] This finding literally revolutionized the comprehension of the physiopathology underlying the motility disorders following BOFs and began to seriously question the previous theory of muscular incarceration as the main mechanism leading to an impairment of ocular movements.[27] He could thus demonstrate that each eye has its own connective tissue system, which is physically related to that of other muscles as well as to the orbital walls. He could then elucidate the paradox of the bizarre form of diplopia of upward and downward gaze in all directions, which could not be explained solely by the entrapment of the inferior rectus and/or inferior oblique muscles.[27] This pattern of diplopia could be explained by considering that the disruption of the connective tissue system of both muscles could lead to a global derangement of the connective tissue system of the other muscles such as the medial and lateral recti and the superior oblique muscles via the traction of the interconnected septa.[27] This anatomical configuration helped to explain why surgical repair, as it is still performed today (i.e., repositioning of the prolapsed tissue and orbital wall reconstruction), is not always optimal in restoring pretrauma ocular motility.[28] In fact, this approach can only improve the component of diplopia related to the macroscopic mechanical entrapment of the orbital tissues and not that related to the microscopic injury of the dense network of connective inter-muscular septa.[28] The problem that remains unsolved is that the initial amount of damage and behavior of the soft tissues over time is unpredictable.

Interestingly, based on previous findings showing that the development of orbital connective tissue depends on ocular movements, Koornneef advocated the importance of eye movement exercises as soon as possible after the trauma to stimulate the regeneration of the septa's connections among the different muscles.[13,23,27]

The advent of the Ct scan: Should we treat images rather than patients?

Although Grove et al.[29] were the first to report on the use of coronal CT scan images in orbital fracture evaluation in 1978, Hawes and Dortzbach[30] were the first to classify BOFs on the basis of raw radiological parameters in 1983. They showed a significant association between the clinical and the fracture's size and the volume of the prolapsed orbital contents as calculated on the orbital tomograms. In 1985, Gilbard et al. inaugurated the CT scan era of BOFs by publishing the first study that related CT findings (soft tissue herniation and IRM position) with clinical presentation and late outcome.[31] From this moment on, the CT scan was rapidly placed at the pinnacle of the decision-making hierarchy relegating the clinical examination to a subordinate role. In 1987, Putterman recognized the utility of using CT scan images, and particularly the position of the inferior rectus muscle, as an aid to guide the decision for surgery in clinically unclear cases.[32] However, he was also an early proponent of the personalized approach to BOF based on clinical grounds.[32]

While Manson et al. [33,34] were pioneers in quantifying the association between the volume of displaced periorbital tissues and the development of enophthalmos, Whitehouse et al.[35] were the first to correlate enophthalmos with the fracture's size. Since then, studies focused mainly on the assessment of the following three CT parameters: fracture's size, soft-tissue prolapses and involvement of the inferior rectus muscle (swelling and degree of protrusion within the maxillary sinus).[36-39] It should be noted that by incorporating CT scan imaging in the decision-making process, the main question has progressively and dangerously drifted from *which patient with an orbital fracture needs surgery?* to *which fracture needs surgery?* This explains why efforts have been directed toward the identification of a "magic" number in terms of fractured surface and/or volume of the entrapped orbital soft tissue that could allow a clear-cut decision about whether to treat surgically or not. This number could never be generated, and the literature has reported quite a wide range (from 1 to 3 cm^2) and/or 50% of the fractured orbital floor as a watershed between surgical and non-surgical management.[1] With regard to inferior rectus muscle involvement, the degree of its protrusion into the maxillary sinus emerged gradually as a reliable predictor of persistent diplopia and/or enophthalmos.[39,40]

The computer assisted surgery era: The discovery of a new world in which everything is possible?

First described in the mid-1990s, computer-assisted surgery (CAS) has dramatically improved the precision and the predictability of reconstructive orbital surgery.[41,42] On the one side, the intraoperative navigation, which provides a simultaneous visualization of both the surgical field and the 3D virtual planning superimposed on the CT images. This allows the surgeon to verify the precision of the orbital implant repositioning in real-time. Moreover, this modality can also be coupled with intra-operative CBCT or CT scan to evaluate the concordance between the planned simulation and the final orbital implant positioning by image fusion.[41,42] On the other side, computer-aided design/computer-aided manufacturing (CAD/CAM) is based on transferring the 3D virtual surgical planning via specific surgical cutting guides and patient-specific implants (PSI).[41,42]

What lessons may we learn from all this knowledge?

By far the most important lesson is that despite the outstanding modern technological armamentarium available, clinical acumen remains the most sophisticated decision-assistive tool in the management of BOF, even in 2020. In recent years, we have witnessed the emergence of a paradox between the constant evolution of new imaging-based technologies improving the precision of orbital reconstruction on the one hand and on the other hand, the inability to determine with precision which BOFs could benefit from these advantages. Imaging has gained a predominant position, often relegating clinical observation to a secondary role and elevating the CT scan findings to the status of the "venerated." Surprisingly, the fracture's size continues to be used by many centers as one of the main parameters driving the indication for surgery.

One must recognize that it is not possible to define an "ideal" stereotyped treatment simply because there is no one category of BOFs, each being defined by the patient in whom it occurs. This is the crux of the matter: the two extreme approaches encountered in the literature as recommendations for all patients, i.e., preventive surgery versus a conservative approach are irrational and unreasonable. The clinical picture for each patient, thus each fracture, depends on a myriad of interrelated factors associated with the trauma and the individual variability of the patients. Moreover, the more subtle human qualitative traits of both clinicians and patients must be taken into account while weighing the risks and benefits of different therapeutic options. For this reason, it is of paramount importance not to fall into the trap of rigidity in fitting patients into standardized categories with their associated non-consensual and non-individualized "average" treatment guidelines.

As demonstrated in other fields of medicine, the actual scenario highlights the limits of an evidence-based approach that fails to include patient variability and relies on average results with an emphasis on the application of quantitative rather than qualitative methods to guide the clinician in determining whether or not to undertake a particular treatment.[43-45]

As such, the heart of the matter can be stated as a question: How can we propose the best option for a particular patient when faced with uncertainty about the most "effective" treatment in which the benefits outweigh the possible risks and complications involved?

Adjunctive aids to deal with the therapeutic "gray zone"

The lack of a "best choice" treatment is not unique to BOF. The literature has recently shown that in medicine almost half of all treatments have insufficient evidence and only 11% have evidence of being beneficial. In between, there is a "gray zone" in the management of many medical dilemmas whose solution relates to "close call" or "preference sensitive" decisions because of scientific uncertainty about outcomes and/or the need to carefully weigh and balance risks versus benefits.[46] The most important variable to take into account when applying "preference sensitive" decisions is the personal and intimate point of view of the patient's perception of risks and benefits. This is strongly linked to each patient's judgment of quality of life. When faced with such scientific uncertainty, other qualitative rather than quantitative humanistic approaches could and should be considered and adopted as rules for the decision-making process. These include but are not limited to the precautionary principle, patient decision-making aids and intuition.[47-50]

Precautionary principle

It is a normative principle encompassing prudent and reasonable measures that help in making decisions,"where scientific information is insufficient, inconclusive, or uncertain." In recent years, its use in making medical decisions has also been invoked for the management of such medical problems for which there is a lack of robust scientific certainty about outcomes of different therapeutic choices.[47] As well summarized by Resnik, in medicine the precautionary principle is a qualitative decision-making method that includes,"reasonable measures to prevent or mitigate threats that are plausible and serious." [47] This principle implies a great responsibility on the part of the practitioner, who must be able to assess the seriousness and the plausibility of the risks underlying a proposed procedure versus therapeutic abstention. This is always in the best interest of each patient.

Patient decision aids

In addition to the precautionary principle, other aids exist to navigate the "terra incognita" of scientific uncertainty.[47,51] Patient decision aids have become the most notable among these. Informational materials (e.g., drawings, videos, pictures and 3D models), coupled with medical counseling, help patients in making specific, deliberate, and informed choices about therapeutic options. This has been defined as "shared decision-making," where clinicians and patients make the best choice together. By using this approach, patients are more involved in decisions about their health and this positively affects the final outcome.[47,50]

Intuition

A further aid in decision-making is intuition, also known as a "gut feeling" or "sixth sense," which relies on a personal perception in a specific situation with no "known" rationale.[48] There is no doubt that this unconscious faculty is intimately related to the practitioner's personal clinical experience, which allows for the recognition of specific clinical patterns.[49]

Illustrative cases:

These are patients with similar imaging characteristics but presenting with different clinical pictures that eventually dictated the final management decision.

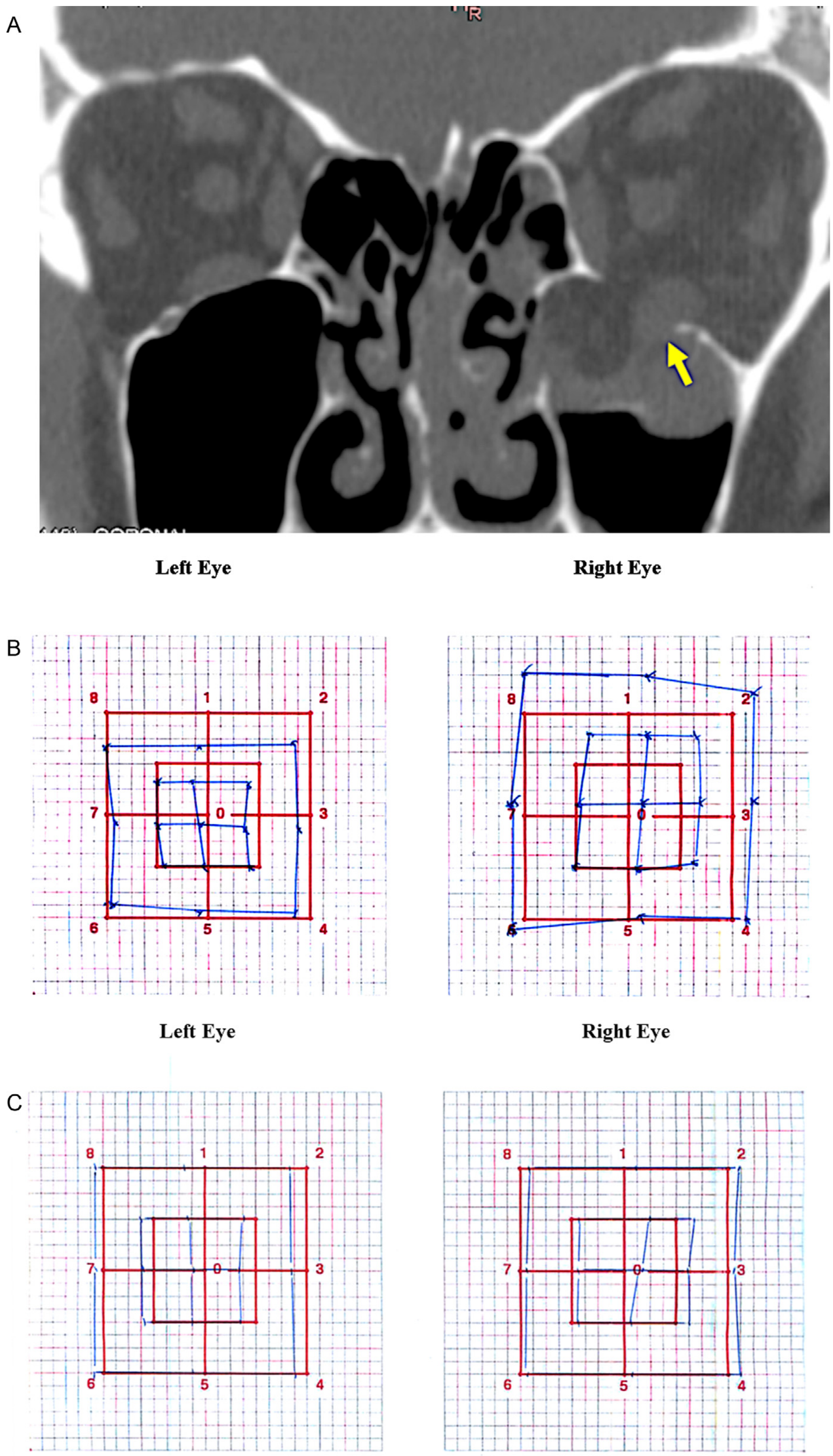

Figure 1 Case 1: Initial post-trauma coronal CT scan images (A) showing a 2.8 cm^2 left displaced blow-out fracture, with a significant herniation of orbital tissues with most of the inferior rectus muscle within the maxillary sinus. The 5-day follow-up Hess-Weiss coordimetry (B) showing a severe limitation of elevation in adduction and abduction of the left eye as well as a limitation of depression in the field of action of the inferior rectus muscle. The 1-year post-trauma Hess-Weiss coordimetry (C) showing a very limited residual diplopia on downward gaze of the left eye.

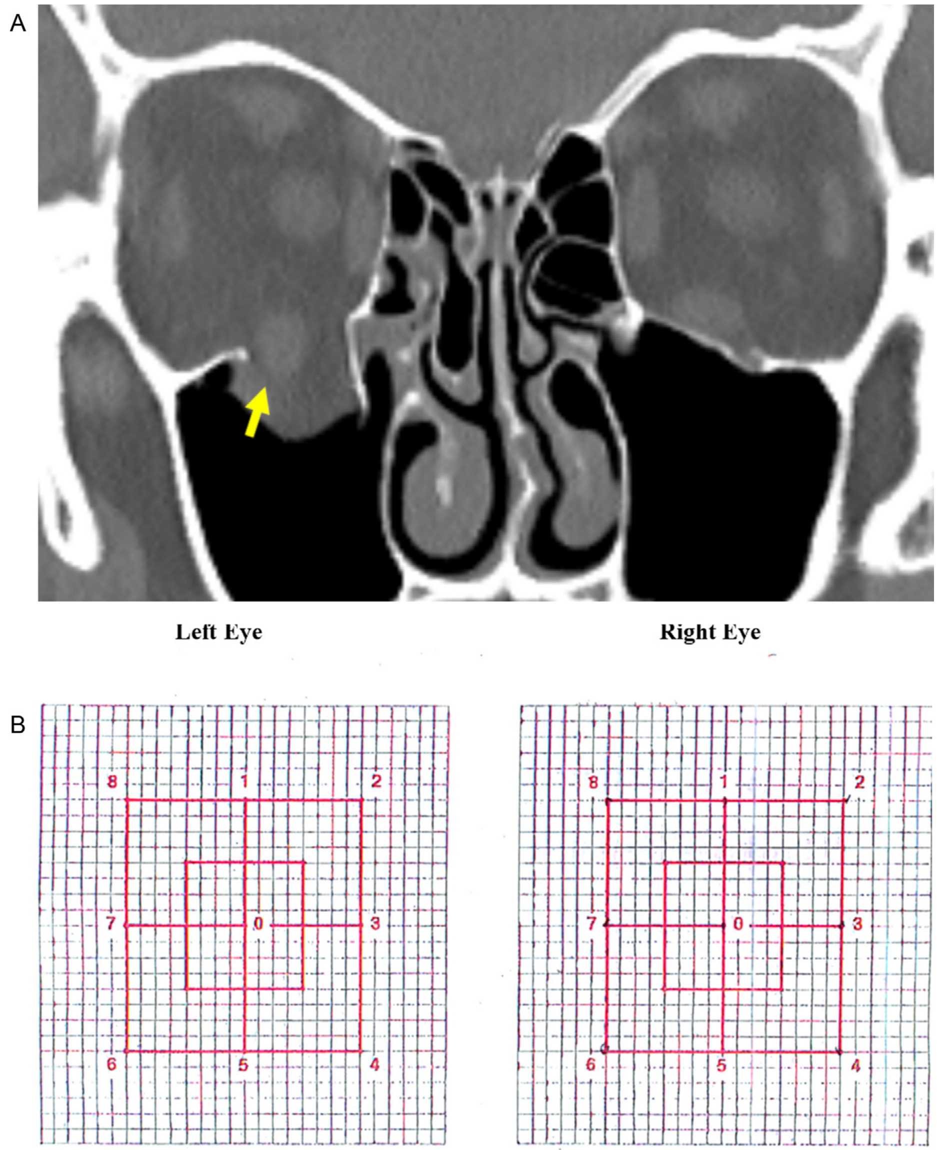

Figure 2 **Case 2:** Initial post-trauma coronal CT scan images (A) showing a 2.5 cm^2 left displaced blow-out fracture, with a significant herniation of orbital tissues with most of the inferior rectus muscle within the maxillary sinus. The identical 10-day and the 1-year (B) posttrauma Hess–Weiss coordimetry showing normal binocular eye motility.

Case 1 (Figure 1)

A 54-year-old man was hit in the face by a fist. Clinical examination revealed marked swelling and ecchymosis in the left periorbital region. Diplopia was present in all fields of upward gaze as well as in the primary position. A CT scan revealed a 2.8 cm^2 left displaced blow-out fracture, with a significant herniation of orbital tissues with most of the inferior rectus muscle within the maxillary sinus. The 5-day follow-up Hess–Weiss coordimetry showed a severe limitation of elevation in adduction and abduction of the left eye as well as a limitation of depression and severe annoying diplopia in the primary gaze (B). Hertel exophthalmometry revealed a 3-mm enophthalmos. Surgical reconstruction by preformed titanium mesh was performed via a transconjunctival approach. The 1-year postoperative Hess-Weiss coordimetry showed an almost complete recovery with a limited diplopia on downward gaze of the left eye that was not interfering with daily activities (C).

This case illustrates a concordance between the amplitude of the fracture's bone defect, the disorder of oculomotricity characterized by annoying double vision in primary gaze and the development of enophthalmos. In such a situation, all of the previously discussed decision aids converged on the only best treatment option, which was surgical.

Case 2 (Figure 2)

A 17-year-old male adolescent was struck by a car. Clinical examination revealed a right periorbital ecchymosis. He had no diplopia and the visual acuity was normal in both eyes. A CT scan revealed a 2.5 cm^2 right displaced blow-out fracture, with a significant herniation of orbital tissues with most of the inferior rectus muscle within the maxillary sinus (arrow) (A). The 10-day follow-up Hess–Weiss coordimetry showed no anomalies, and the patient was orthophoric (B). The patient was reevaluated at 6 weeks and the Hess-Weiss coordimetry was strictly normal. Hertel exophthalmometry revealed a minimal 3-mm enophthalmos not visible to the naked eye and not disturbing the patient's vision. In light of these results, no further follow-up visits were scheduled.

This case depicts an atypical situation in which there is a complete discrepancy between the severity of the fracture defect and the absence of any ocular motility defect and accompanying diplopia. The only clinical anomaly was a mild enophthalmos. In such a case, there is a great temptation to propose a surgical approach on the pretext of the size of the fracture (>2 cm^2) as well as the risk of the development of an unaesthetic enophthalmos. Instead, clinical intuition and common sense together with the patient's input directed us toward the precautionary choice of observation, which in the end proved to be the best decision for this patient.

Conclusions

The main knowledge learned from the past can be summarized by the following observations.

Reconstructive surgery can have an impact only on the mechanical and restrictive component of the diplopia. This diplopia is related to the macroscopically visible prolapsed outer portion (extra-conal) of the motility apparatus that anchors extra-ocular muscles to the orbital walls. Conversely, the component of diplopia related to the disrupted inner portion (intra-conal) that anchors the globe to the extra-ocular muscles and/or a direct injury of such muscles cannot be influenced by reconstructive bone surgery. Thereby, the indication for bone reconstructive surgery should be driven by mechanical diplopia. Only a comprehensive orthoptic evaluation and not CT scan imaging can determine which component of diplopia is predominant.

Until 2016, in our service, the decision for surgery in cases presenting with an unclear clinical picture was dictated by geometrical CT scan parameters such as the fracture size, the amount of musculo-fibrofatty orbital tissue herniation and increasing orbital volume. For the last 5 years, we have carefully scrutinized every single case of BOFs. The data forced us to make a *mea culpa*, while reinforcing our thinking that surgical repair of BOFs should be regarded more as a clinical problem of annoying “double vision” rather than a mere geometrical imaging issue. This led us to change our approach to pure clinically oriented decision-making for individual patients. The consequences of such an approach have been a shift towards a more conservative approach and thus a substantial decrease in indications of surgical repair. By adopting this approach, we do not deny the importance of imaging, but rather we readjust its use as adiagnostic rather than a decision-making tool. In the end, I would like quote Sir William Osler that well summarizes the essence of the present reflection: “The good physician treats the disease; the great physician treats the patient who has the disease.”

Declaration of competing interest

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Ethical approval

The study was conducted in accordance with the Declaration of Helsinki and was approved by our local Ethical Board (Study number 12–255).

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