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How reliable is the visual appraisal of a surgeon for diagnosing orbital fractures?

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ABSTRACT

Purpose: The aim of this study was to evaluate the usefulness of intra-operative visualisation, endoscopic assistance, and CT measurements for estimating the orbital fracture size and complexity.

Methods: Ten human cadaver heads were subjected to thin-slice computed tomography (CT). Standardised fractures were created using piezoelectric surgery in accordance with the Jaquiéry classification system. Four surgeons and one anatomist used six different observation methods to visualise and describe the orbital defects.

Results: The intraclass correlation coefficients (ICCs) for the fracture length measurements were relatively low for all observation methods (range, 0.666–0.883). CT measurements of width showed high consistency (ICC, 0.910). The surface area of the defect was highly overestimated by all methods (range, 121–184%). None of the observers was able to accurately estimate the length or width of 95% of the defects within an error range of ±0.75 cm.

Conclusion: CT measurements are the most consistent and accurate tool for estimating the critical size of orbital factures. In daily practice, a measurement tool in a DICOM viewer could be used, although software packages that allow manual adjustments are advisable. Direct intraoperative visualisation and surgeon experience are of limited value in the estimation of fracture size and complexity, and endoscopy provides no additional advantages.

1. Introduction

The goals of orbital reconstruction surgery include repair of the traumatic defect and restoration of ocular function by lifting the globe into position and elevating the dislocated and sometimes incarcerated soft tissue in order to avoid clinical symptoms such as enophthalmos, hypoglobus, and diplopia. Unfortunately, clinical decision making with regard to the management of patients with orbital fractures can be challenging (Ewers et al., 2005; Dubois et al., 2015c, 2015d, 2016). The indications for surgical intervention and the choice of implant material are directly influenced by the complexity of the case. Larger and more complex fractures are more susceptible to adverse treatment outcomes and require a different treatment protocol than small and solitary orbital wall fractures (Burnstine, 2002; Ewers et al., 2005; Jaquiéry et al., 2007; Metzger et al., 2007; Wajih et al., 2011; Kunz et al., 2013; Dubois et al., 2015d). For example, if >50% of the surface area of the orbital medial wall or floor is missing, the risk of developing enophthalmos is considerable, which enhances the need for surgical correction. However, the reliability of this indicator remains questionable.

Once an indication for surgery is established, the first step in orbital reconstruction is to estimate the size and location of the

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defect. This helps the surgeon to select the most suitable reconstruction material. In conventional orbital reconstruction, implants that can be manually bent require intraoperative adjustment to match the specific orbital defect. Consequently, the surgeon is forced to estimate the length, width, and surface area of the defect before adjusting the implant. Estimation errors may lead to incorrect dimensions and positioning of the orbital implant and a poor clinical outcome.

Computed tomography (CT) is recognised as the best imaging technique for evaluating orbital fractures (Bite et al., 1985; Manson et al., 1986; McGurk et al., 1992; Charteris et al., 1993; Harris et al., 1998). Additionally, software-based, virtual, three-dimensional (3D) reconstructions help surgeons with the decision-making process (McGurk et al., 1992; Charteris et al., 1993; Raskin et al., 1998), resulting in more rational choices. Systematic reviews on orbital reconstruction have revealed that surgeons based their surgery-related decisions on CT findings (fracture size, incarcerated tissue) in almost half of the cases analysed (Gunarajah and Samman, 2013; Dubois et al., 2015c). Such reviews suggest that in approximately 19% of cases, a CT finding of a fracture involving >50% of the surface area was a primary indicator for orbital reconstruction (Burnstine, 2002; Gunarajah and Samman, 2013).

The newest technology in orbital reconstruction is computer-assisted surgery (CAS), which includes a preoperative diagnostic and planning phase, an image-guided navigation phase, and an intraoperative control phase. The first phase allows the surgeon to use all of the information in the Digital Imaging and Communications in Medicine (DICOM) dataset. The original anatomy can be simulated using segmentation and mirroring tools (Schramm et al., 2009; Gander et al., 2015). This additional information is beneficial for optimising diagnostics (Shah et al., 2013), and contributes greatly to the surgeon's preparation before the actual procedure is performed. Stereolithographic (.stl) files of preformed or patient-specific implants can be fitted in the digital environment, and with the integration of intraoperative navigation and imaging in the treatment protocol, this helps optimise the process (Lieger et al., 2010; Dubois et al., 2015a, 2015b; Rana et al., 2015). Unfortunately, these technological possibilities are only available in select, well-equipped centres. Even though the amount of extra time required for CAS is not excessive (Schramm et al., 2009; Dubois et al., 2015b), some surgeons prefer to rely on their experience to achieve an acceptable result. However, recently published studies suggest that experience does not always lead to better diagnoses (O'Toole et al., 2009; Komerik et al., 2014) or yield consistent results (Leenders et al., 2002; Ganapathi et al., 2009; Brin et al., 2011; Dubois et al., 2015a, 2015b; Stiehler et al., 2015).

The aim of this study was to compare direct intraoperative and endoscopic visualisation with CT observations to identify the most reliable method for determining the size, location, and complexity of orbital fractures. The effect of the surgeon's experience on the accuracy of the estimations was also assessed.

2. Methods

Ten human cadaver heads were obtained from the body donation program of the Department of Anatomy, Embryology, and Physiology at the Academic Medical Center of the University of Amsterdam. Institutional review board approval was waived for this study. One of the 20 orbits was excluded due to sinus pathology (osteoma); thus, 19 orbits were used in this study. Each head was labelled. The orbital floor and medial wall were fully exposed via a standard transconjunctival incision and retroseptal preparation. Using the Jaquiéry classification system (Jaquiéry et al., 2007; Kunz et al., 2014) (Fig. 1), class I to IV orbital defects were created by piezoelectric surgery (Mectron, Carasco, Italy) in the orbital floor as shown in Fig. 2. The size and location of the created defects in the cadavers varied. Via a buccogingival incision, a 5-mm antrostomy was created by piezoelectric surgery in the concavity of the canine fossa to facilitate inspection with a 0° or 30° rigid endoscope. The overlying sinus mucosa was removed.

Four surgeons (three oral and maxillofacial surgeons, one otolaryngologist) and one anatomist used six different observation methods to visualise and describe the orbital defect sizes and locations, as follows: (1) estimation from a transconjunctival approach (direct intraoperative visualisation), (2) estimation from a transantral endoscopic approach with a 0° scope, (3) estimation from a transantral endoscopic approach with a 30° scope, (4) estimation from a transconjunctival endoscopic approach with a 0° scope, (5) estimation based on CT images only (without the aid of software), and (6) digital measurements on CT images (with the aid of software).

The assessors were blind with regard to the specimen numbers. Each observer was instructed to perform a standardised examination of each fracture by using one of the observation methods listed above. For the transconjunctival observations, both the inferior orbital fissure and the transition zone between the floor and medial wall needed to be located. Before endoscopic observation, all observers were asked to identify the following three landmarks to aid in orientation: the infraorbital nerve, sinus ostia, and posterior shelf (as defined by Moore et al., [2008]). Then, they were asked to assess the fracture and record its location, size (length, width, and surface area), and classification.

2.1. CT analysis

CT scans (Sensation 64; Siemens Medical Solutions, Forchheim, Germany) of the cadaver heads were acquired with intact orbits (baseline, T0) and after the creation of the orbital defects (T1). The scanning parameters were as follows: collimation, 20.0 × 0.6 mm; 120 kV; 350 mAs; pitch, 0.85; field of view, 30 cm; matrix size, 512 × 512; reconstruction slice thickness, 0.75 mm with overlapping increments of 0.4 mm; bone kernel, H70s; and bone window, W1600 L400. DICOM data for the T0 and T1 scans were imported into iPlan version 3.0.5 (Brainlab AG, Feldkirchen, Germany). The image volumes were fused using the image fusion function. Atlas-based segmentation of the intact orbit was performed using the T0 scans, whereas the border of the defect was segmented based on information from the T0 and fused T1 scans.

The segmentations of the bony orbit and defect outline were exported as.stl files and imported into 3DS Max version 2012 (Autodesk Inc., San Rafael, CA, USA). The surface area of the intact orbit was extracted from the model based on the outline of the segmented defect (Fig. 3). Length, width, and surface area measurements of the extracted object, representing the surface area of the orbit on the T0 scan at the location of the defect on the T1 scan were obtained and considered to be the actual defect dimensions.

2.2. Statistical analysis

The observers estimated the maximal sagittal distance (length), transverse distance (width), surface area, and Jaquiéry classification of each fracture using the six observation methods listed above. Statistical analysis was performed using SPSS version 21.0 (IBM Corp., Armonk, NY, USA). Interobserver agreement was calculated using the intraclass correlation coefficient (ICC), where an ICC of 0 indicates no agreement, while an ICC of 1 indicates perfect agreement. Paired-samples *t*-tests were performed to assess the significance of the differences between the measurements obtained using the different observation methods and the differences between the two-dimensional (2D) and 3D surface area measurements.