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Predictability in orbital reconstruction: A human cadaver study. Part I: Endoscopic-assisted orbital reconstruction

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ABSTRACT

In the treatment of orbital defects, surgeon errors may lead to incorrect positioning of orbital implants and, consequently, poor clinical outcomes. Endoscopy can provide additional visualization of the orbit through the transantral approach. We aimed to evaluate whether endoscopic guidance during orbital reconstruction facilitates optimal implant placement and can serve as a convenient alternative for navigation and intra-operative imaging. Ten human cadaveric heads were subjected to thin-slice computed tomography (CT). Complex orbital fractures (Class III/IV) were created in all eligible orbits ($n = 19$), which were then reconstructed using the conventional transconjunctival approach with or without endoscopic guidance. The ideal implant location was digitally determined using pre-operative CT images, and the accuracy of implant placement was evaluated by comparing the planned implant location with the postoperative location. There were no statistically significant differences ($p > 0.05$) in the degree of implant dislocation (translation and rotation) between the transconjunctival orbital reconstruction and the endoscopic-assisted orbital reconstruction groups. Endoscopic-assisted orbital reconstruction may facilitate the visualization of orbital defects and is particularly useful for training purposes; however, it offers no additional benefits in terms of accurate implant positioning during the anatomical reconstruction of complex orbital defects.

1. Introduction

Complex orbital fractures may cause functional and cosmetic post-traumatic impairment. Adequate reconstruction is crucial for a satisfactory surgical outcome, although it is difficult to achieve (Hammer, 1995). The complexity of orbital fracture repair is well documented (Burnstine, 2002). These fractures are associated with less accurate reconstruction because of the potential for suboptimal implant placement, which may result in disabling enophthalmos and diplopia (Dubois et al., 2015b). From a surgical perspective, the most complex orbital fractures are characterized by large defects accompanied by loss of the majority of the orbital structures in the floor and medial wall regions. For the reconstruction of large defects, an additional visualization tool may be beneficial. Intra-operative endoscopy may cost less and be easier to use than image-guided navigation or peri-operative imaging, and it is steadily gaining popularity; however, the availability of this modality is limited to a few well-equipped centres (Bell and Markiewicz, 2009; Marckiewicz et al., 2012; Essig et al., 2013; Schreurs et al., unpublished results).

For the surgical repair of complex orbital fractures, most surgeons choose the conventional transcutaneous or transconjunctival

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approach, which allows proper visualization of the defect size and location (Dubois et al., 2015a). The goal of reconstruction is to restore function and aesthetics by recontouring the bony orbit to its anatomical shape. However, visualization may be difficult during repositioning of the prolapsed orbital tissue from the sinuses into the orbit and during recontouring of the walls during placement of the orbital implant. Small errors in orbital floor implant positioning can cause both functional and cosmetic complications (Manson et al., 1986; Rana et al., 2012). One of the most common reasons for inaccurate implant placement is the inability to accurately define the posterior orbital ledge, which is formed by the orbital process of the palatine bone and extends as part of the orbital floor at the transition zone from the inferior orbital fissure to the superior orbital fissure. Implant placement on this ledge is important to ensure posterior support, although it can be challenging. The ledge must be cleared of all soft tissue, while the adjacent orbital fat and optic nerve must remain undisturbed (Kakibuchi et al., 2004).

Transantral endoscopic surgical repair for orbital floor fractures has gained popularity in recent years (Jin et al., 2007; Ducic, 2009; Hundepool et al., 2012; Balakrishnan and Moe, 2011; Polligkeit et al., 2013; Farwell et al., 2014). In 1950, Converse and Smith (1950) described a technique for palpation of the orbital floor through the maxillary sinus before conversion to transorbital exploration. Walter later used the transmaxillary pathway to visualize and repair orbital floor fractures (Walter, 1972). Because the maxillary sinus provides a confined surgical space, endoscopic management of orbital floor fractures is technically the easiest. Trans-sinusoidal endoscopy reportedly offers excellent visualization and allows confirmation of secure and accurate implant placement (Strong, 2004).

Strong (2004) advocated that the indications for endoscopic repair are identical to those for conventional repair. Other studies reported that the predictable, completely endoscopic repair of orbital fractures is limited to trapdoor fractures in which no implant placement is made, or only small implants are used (Kakibuchi et al., 2004; Shi et al., 2012). Even with these limited therapeutic indications, up to 15% of intended endoscopic approaches to the orbit are converted to an open approach (Farwell and Strong, 2006). In patients with large orbital defects involving the medial wall and floor, the transorbital approach is mandatory for clear exposure and placement of solid implant material. Therefore, a combined endoscopic and transorbital approach was suggested to enable dual examination and manipulation of the orbital implant by the surgeon, with the goal of improving the outcome of surgical repair of orbital floor fractures (Kakibuchi et al., 2004; Kwon et al., 2008; Hundepool et al., 2012). A previous study suggested that this combined approach minimizes the risk of inaccurate implant positioning (Chen and Chen, 2010). The potential major complications of endoscopic orbital floor repair are similar to those of the open approach, including blindness, persistent diplopia or residual enophthalmos. Unfortunately, none of the previous studies employed a well-defined classification scheme for orbital fractures, and all were retrospective in nature (Kakibuchi et al., 2004; Jin et al., 2007; Kwon et al., 2008; Chen and Chen, 2010; Balakrishnan and Moe, 2011; Hundepool et al., 2012). In addition, most studies lacked a control group (Kakibuchi et al., 2004; Kwon et al., 2008; Chen and Chen, 2010), included small patient samples (4–48 patients) and used different reconstruction materials.

The aim of this study was to assess the benefits of endoscopic-assisted reconstruction (EAR) for ideal implant positioning in patients with standardized complex orbital defects (Class III–IV). Specifically, the accuracy of implant positioning was compared between conventional transconjunctival reconstruction (TCR) and EAR in human cadaveric models.

2. Materials and methods

2.1. Materials

Ten human cadaveric heads (20 orbits) were obtained from the Department of Anatomy of the Academic Medical Hospital, the University of Amsterdam. Of the 20 orbits, one was excluded because of sinus pathology (osteoma); therefore 19 orbits were included in this study.

The orbital floor and medial wall were fully exposed through a standard transconjunctival incision, and complex orbital defects (Class III–IV) were created by piezosurgery according to the Jaquiéry classification (Jaquiéry, 2007; Kunz et al., 2013). A gingivobuccal incision was placed, and a 5-mm antrostomy was created by piezosurgery (Mectron, Carasco, Italy) in the concavity of the canine fossa to facilitate endoscopic inspection. The sinus mucosa was removed to facilitate inspection of the defect contours. The cadaveric heads were subjected to computed tomography (CT; Sensation 64, Siemens Medical Solutions, Forchheim, Germany) at baseline (with intact orbits, T0), after creation of the orbital defects (T1) and after implant placement (T2). The scanning parameters were as follows: collimation, 20 × 0.6 mm; 120 kV; 350 mAs; pitch, 0.85; field of view, 30 cm; matrix, 512 × 512; reconstruction slice thickness, 0.75 mm with 0.4-mm overlapping increments; bone kernel, H70s; and bone window, W1600 L400.

2.2. Validation study

The consistency of reconstruction was first assessed in a validation study. Two oral and maxillofacial surgeons (LD and PG), both experienced in orbital reconstruction, performed the operations on each human specimen using either a solitary transconjunctival or a combined (transconjunctival and endoscopic) approach. Preformed orbital titanium mesh plates (KLS Martin, Tuttlingen, Germany) were used. The drill holes were covered and camouflaged between the two sessions by filling with DuraLay (Reliance Dental Mfg. Co, Worth, IL, USA). Each orbit was reconstructed and scanned six times in total. Inter- and intra-surgeon variability was determined using the inter-class correlation coefficient (ICC).

3. Methods

In the first surgical session, all orbits ($n = 19$) were reconstructed by one surgeon (LD) through the conventional transconjunctival approach. Reconstruction was performed again in a second session using a combined transconjunctival and transantral endoscopic approach by the same surgeon. A 30° endoscope (Storz, Tuttlingen, Germany) was placed by the assisting surgeon (JJ), and orbital prolapse was reduced using the transconjunctival approach. Reduction of the orbital prolapse was visualized both transconjunctivally and endoscopically. The implant was placed in a presumably adequate position, and the placement was verified using a bidirectional view. The implants were fixed with a single bone screw, and the specimens were scanned according to protocol. After scanning, the implants were removed and the drill holes were covered and camouflaged by filling with DuraLay (Reliance Dental Mfg. Co., Worth, IL, USA). The surgeons completed a questionnaire about their perception of the predictability and quality of the reconstruction. For consistency in measurements, one surgeon (LD) performed the reconstructions twice in both groups.

3.1. Contour analysis

The quality of the reconstructions was assessed using iPlan software (version 3.0.5, BrainLAB AG, Feldkirchen, Germany). The