Radiography 22 (2016) e228–e232

Contents lists available at ScienceDirect

Radiography

journal homepage: www.elsevier.com/locate/radi

Substantial CT radiation dose reduction does not affect the preference for CT over direct digital radiography to diagnose isolated zygomatic fractures – A study in human cadavers

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ARTICLE INFO

Article history:
Received 16 March 2016
Received in revised form
11 July 2016
Accepted 31 July 2016
Available online 25 August 2016

Keywords:
Zygomatic fractures
Diagnostic imaging
Radiography
X-ray computed tomography
Radiation dosage

ABSTRACT

Introduction: Zygomatic fractures can be diagnosed with either computed tomography (CT) or direct digital radiography (DR). The aim of the present study was to assess the effect of CT dose reduction on the preference for facial CT versus DR for accurate diagnosis of isolated zygomatic fractures.
Materials and methods: Eight zygomatic fractures were inflicted on four human cadavers with a free fall impactor technique. The cadavers were scanned using eight CT protocols, which were identical except for a systematic decrease in radiation dose per protocol, and one DR protocol. Single axial CT images were displayed alongside a DR image of the same fracture creating a total of 64 dual images for comparison. A total of 54 observers, including radiologists, radiographers and oral and maxillofacial surgeons, made a forced choice for either CT or DR.
Results: Forty out of 54 observers (74%) preferred CT over DR (all with $P < 0.05$). Preference for CT was maintained even when radiation dose reduced from 147.4 μSv to 46.4 μSv (DR dose was 6.9 μSv). Only a single out of all raters preferred DR ($P = 0.0003$). The remaining 13 observers had no significant preference.
Conclusion: This study demonstrates that preference for axial CT over DR is not affected by substantial (~70%) CT dose reduction for the assessment of zygomatico-orbital fractures.

Introduction

The orbito-zygomatic area represents the major fracture site among maxillofacial traumas.[1–4] Traffic accidents and assault have been described as the main causes of zygomatic fractures.[1,4–6] It has been demonstrated that early and correct diagnosis are important factors determining treatment outcome.[7–9] Both clinical examination and diagnostic imaging are used for the assessment of potential zygomatic fractures. Isolated zygomatic fractures are suspected after midface trauma with low clinical index of suspicion for orbital or visual complications. Computed tomography (CT), direct digital radiography (DR) and Cone Beam Computed Tomography (CBCT) are the current imaging modalities to assess zygomatic fractures.[9–11] This study focuses on the use of CT and DR due the current lack of CBCT accessibility in the emergency department.

In many cases, DR is first choice to check bone integrity after facial trauma. It is quick, easy accessible in most hospitals and associated with low radiation dose.[11] Apart from these benefits, DR has a few imperative disadvantages. First, the positioning of the head can be difficult causing discomfort to the patient. Second, the images are relatively difficult to interpret due to superimposition of bone structures. Finally, if the assessment is inconclusive, patients need to undergo an additional CT scan, thereby adding to radiation burden. Nowadays, in most emergency room (ER) settings CT is

Abbreviations: CBCT, cone beam computed tomography; DR, direct digital radiography; CT, computed tomography; MPR, multiplanar reconstructions; OMF, oral and maxillofacial.

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http://dx.doi.org/10.1016/j.radi.2016.07.007
1078-8174/

very easily accessible. Compared to DR, multidetector CT requires considerable less time, is safer, and more comfortable for patients.[12–15] The question however remains whether or not the high radiation dose is justified in cases of non-complex maxillofacial trauma, like zygomatic fractures. The use of low dose CT might combine the advantages of CT and DR, but it is unclear to what extend low dose CT images are preferred compared to DR for diagnosing zygomatic fractures. The aim of the present study therefore was to assess the effect of CT dose reduction on the preference of radiographers, radiologists and oral and maxillofacial (OMF) surgeons for facial CT versus DR for accurate diagnosis of isolated zygomatic fractures.

Material and methods

Research design

Zygomatic fractures were inflicted on four human cadaver heads. Subsequently, both CT and DR images were generated. Multi spiral CT scans were performed with linear dose reduction as achieved by raising the noise index for eight different CT protocols. Evaluation of the images was performed by a panel of 54 independent observers, consisting of 37 radiographers, 13 radiologists and 4 OMF surgeons. Selection criterion for participating in the observer group was to have clinical experience in generating and technically evaluating both CT and DR images for their diagnostic value in clinical practice for at least one year. Observers compared CT images with DR images in random order during a double blind forced choice comparison test, *i.e.* both the researchers and observers were blinded for the scan parameters that were used to generate the presented CT image.

Human cadaver heads

Four fresh Caucasian adult human cadavers (two males and two females) were used in this study. Their age ranged from 72 to 87 yr. The human cadavers were purchased from and provided by the section anatomy of the Department of Neurosciences of the University Medical Center Groningen, Groningen, the Netherlands. Legal and ethical approval for the use of the human cadavers was provided by the section anatomy of the Department of Neurosciences of the University Medical Center Groningen, Groningen, the Netherlands. All experiments were conducted in collaboration with the conservators of the Anatomy Section and were executed according to standards for working with human cadavers as provided by Dutch law.

Infliction of zygomatic fractures

A blunt trauma was systematically inflicted using 2.0 kg weights and a free fall impact in attempt to inflict zygoma-orbital fractures typically found in clinical practice. During a vertical drop, a 160 cm tube guided the weights to the malar eminence (Fig. 1). A calculation based on the biomechanical tolerance force of the zygomatic bone indicated a minimal drop height of 72 cm.[16] The human cadaver heads were placed on a 52° wooden wedge to ensure perpendicular impact on the malar eminence (Fig. 2). An OMF surgeon clinically examined the midface of the specimen after impact, focusing on flattening of the cheek and steps at the infraorbital rim or at the location of the zygomatic alveolar crest in order to confirm the zygoma-orbital fractures. Fractures were inflicted on both the left and the right zygoma within each cadaver head.

Figure 1. Infliction of the zygomatic fractures. The zygoma-orbital fractures were systematically inflicted on the cadaver head using 2 kg weights and a free fall impact. A 160 cm tube guided the weights to the malar eminence during a vertical drop.

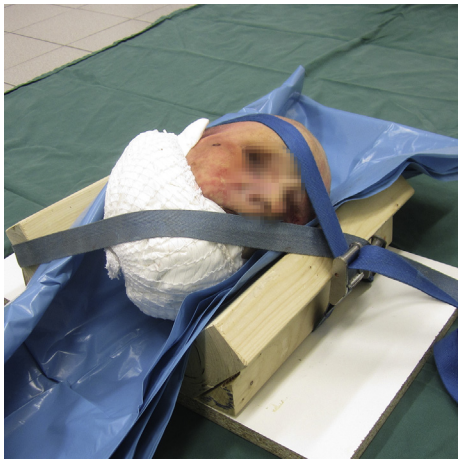

Figure 2. Placement of the human cadaver heads for the infliction of the zygomatic fractures. The cadaver heads were placed on a 52° wooden wedge to ensure perpendicular impact on the malar eminence. In the picture, the face was pixelized for ethical reasons.

Computed tomography

The zygomatic-orbital fractures were scanned using a GE Lightspeed Ultra 8 Slice CT (General Electric Co., Fairfield, Connecticut, United States). Facial multidetector CT was performed using the acquisition parameters as reported in Table 1. Linear dose reduction was achieved by raising the noise index for eight different CT protocols (Table 1). The effective dose was calculated using dose length products (DLP) and conversion factors according to the European guidelines on quality criteria for computed tomography.[17]

Direct digital radiography

DR images were generated using a calibrated Oldelft Canon Triathlon DR (Oldelft Benelux Ltd., Veenendaal, The Netherlands). Details regarding the acquisition parameters were provided in Table 2. For each specimen four different DR images were taken. The cadaver heads were positioned on a bed for occipitomental projection. From this position DR images were generated 15° craniocaudal, perpendicular vertical (Waters), 15 and 30° caudocranial