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Short communication

The effect of decreasing computed tomography dosage on radiostereometric analysis (RSA) accuracy at the glenohumeral joint

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ABSTRACT

Standard, beaded radiostereometric analysis (RSA) and markerless RSA often use computed tomography (CT) scans to create three-dimensional (3D) bone models. However, ethical concerns exist due to risks associated with CT radiation exposure. Therefore, the aim of this study was to investigate the effect of decreasing CT dosage on RSA accuracy. Four cadaveric shoulder specimens were scanned using a normal-dose CT protocol and two low-dose protocols, where the dosage was decreased by 89% and 98%. 3D computer models of the humerus and scapula were created using each CT protocol. Bi-planar fluoroscopy was used to image five different static glenohumeral positions and two dynamic glenohumeral movements, of which a total of five static and four dynamic poses were selected for analysis. For standard RSA, negligible differences were found in bead (0.21 ± 0.31 mm) and bony landmark (2.31 ± 1.90 mm) locations when the CT dosage was decreased by 98% (p-values > 0.167). For markerless RSA kinematic results, excellent agreement was found between the normal-dose and lowest-dose protocol, with all Spearman rank correlation coefficients greater than 0.95. Average root mean squared errors of 1.04 ± 0.68 mm and $2.42 \pm 0.81^\circ$ were also found at this reduced dosage for static positions. In summary, CT dosage can be markedly reduced when performing shoulder RSA to minimize the risks of radiation exposure. Standard RSA accuracy was negligibly affected by the 98% CT dose reduction and for markerless RSA, the benefits of decreasing CT dosage to the subject outweigh the introduced errors.

1. Introduction

Computed tomography (CT) is a popular tool for medical diagnostics (Vanhoenacker et al., 2007) and biomechanical research (Beimers et al., 2008). Three-dimensional (3D) models created from CT have been used to measure skeletal kinematics using radiostereometric analysis (RSA; Tashman and Anderst, 2003). There are two main types of RSA: standard and markerless. Standard RSA is based on tracking markers embedded in bone (Tashman and Anderst, 2003), which can then be related to anatomical landmarks using CT. Markerless RSA is performed by matching 3D computer models of bones, often created using CT, to their outlines on radiographs (Asano et al., 2001).

There are ethical concerns associated with CT use because of the risks of radiation exposure (Ron, 2003). Therefore, every attempt should be made to reduce this exposure, especially near the torso, such as at the shoulder, as radiation dose increases significantly as more proximal structures are scanned (Biswas et al., 2009).

In a clinical setting, studies have reported CT dose reductions of 33% (Bonel et al., 2005) and 75% (Gurung et al., 2005), while maintaining satisfactory diagnostic image quality. The effect of decreasing CT dosage on 3D computer models used for research has also been examined at the radius and ulna (Oka et al., 2009) and at other bones with little surrounding soft tissue (Van Sint Jan et al., 2006). Large acceptable dose reductions of 90% (Van Sint Jan et al., 2006) and 97% (Oka et al., 2009) were achieved. However, these results cannot be translated to other anatomical joints, such as the shoulder, because they have considerably more surrounding soft tissue. Therefore, the aim of this study was to analyze the effect of reducing CT dosage on the accuracy of fluoroscopic-based

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