Utility of Standard versus Metal Suppression CT in Evaluating Intraarticular Ballistic Penetration: A Cadaveric Study

Aneesh V Samineni, David S Constantinescu, Joseph P. Costello, Spencer W Barnhill, Abeer Al Barghouthi, Leon Volovelsky, Gregory A Zych, Loren L Latta

INTRODUCTION:

Between 60,000 and 80,000 nonfatal gunshot injuries occur annually in the United States. Complications of retained intra-articular metallic foreign bodies include infection, lead poisoning, impaired chondrocyte function, pain and continued mechanical damage to both the overlying cartilage and subchondral bone. Intra-articular penetration is an indication for surgical removal while bullet or bullet fragments located in the surrounding soft are often not removed. Currently, there is limited to no literature evaluating the accuracy of common radiographic tools including computed tomography (CT) at determining whether a foreign body has penetrated the articular surface

In trauma cases with metal bullets present, CT images are often obscured by artifact. The study aims to determine the accuracy of CT imaging protocols in evaluating the degree of intra-articular protuberance of a bullet.

Our primary objective is to determine whether there is a difference between the two CT imaging modalities in assisting orthopaedic surgeons and radiologists taking trauma call to accurately determine if a foreign lead bullet has penetrated the articular surface of the ankle joint, as well as the perceived distance from the joint.

METHODS: A human cadaver ankle joint including the foot and distal half of the tibia was prepared to introduce a bullet into the medullary canal and control its position in and near the ankle joint (Figure 1. Cadaveric model). The cadaver had a bullet casing placed in the distal aspect of the tibia at -1 mm, -0.5 mm, 0.0 mm, +0.5 mm, +1 mm with relation to the joint. Positive values indicate distance protruding inside the joint while negative numbers indicate bullet is not in the joint. The medullary canal was reamed through the distal tibia into the ankle joint. The bullet was placed in a clear plastic tube that fit into the reamed medullary canal so the position of the bullet could be controlled with a non-metallic apparatus. The levels of protuberance were assessed with standardized regular CT and metal suppressed CT (0.6mm slices) (Figure 2. Standard CT and metal suppression protocols). CT images were prepared into a survey which asked whether the viewer believed the bullet was in the joint, the approximate distance, their confidence using a Likert scale, if metal scatter affected their decision, etc. Participants were able to review axial and sagittal cuts of all CTs without time limit. Surveys were sent across six Level 1 hospitals throughout the United States to orthopaedic surgery and radiology residents, fellows, and attendings – all who take trauma call. Responses were collected and analyzed between CT images with metal suppression versus without.

RESULTS:

A total of 34 participants: 28 orthopaedic surgery and radiology residents (PGY1-5 were represented), 1 MSK radiology fellow, and 5 orthopaedic trauma and radiology attendings (years in practice ranging from 1 to 21) participated in the survey.

Metal suppression significantly improved the proportion of participants who correctly identified whether the bullet was intraarticular for the -1.0mm (93.6% v 45.2%, $p<0.001$) and -0.5mm (76.7% v 23.3%; $p <0.001$) specimens. There were no significant differences in the +1.0mm, +0.5mm, or 0.0mm specimens. Comparing average Likert confidence scores of individuals who correctly determined if the bullet was intra-articular, only the +1.0mm cohort demonstrated significantly higher confidence levels in their selection ($p=0.023$). Regardless of the presence or absence of metal suppression, the sagittal plane was overwhelmingly the preferred plane for viewing the imaging (79.0%). Participants who identified metal scatter as present stated their clinical decision making was generally influenced more often the closer the bullet was to the articular surface (-1mm, 35.7%; -0.5mm, 53.9%; 0mm at joint, 53.3%; +0.5mm, 33.3%; and +1mm 36.8%).

DISCUSSION AND CONCLUSION:

This study shows that metal suppression greatly assisted with correctly identifying when the bullet is not in the joint; however, it did not have a difference compared to standard protocol for instances when the bullet was in the joint. Furthermore, several participants (33-54% depending on the distance) indicated that metal scatter affected their decision making. Over half mentioned metal scatter impacted their decision making for the -0.5mm and 0mm distances.

In conclusion, metal suppression CT has the potential to assist both orthopaedic surgeons and radiologists to determine whether a bullet has penetrated the articular surface into the joint, as assessed by accuracy and self-reported confidence levels of responses. The potential of this clinical impact can mean the difference between operative and nonoperative management.

To our knowledge, this is the first study investing the importance of metal suppression in comparison to standard CT protocols for determining the intra-articular nature of a bullet.

Although the current study only includes 34 members, it will continue to be distributed among more level 1 trauma centers, allowing us to granulate further, comparing accuracy among residents based on PGY level, fellows, and

attending surgeons. In conclusion, CT with metal suppression is an important tool determining intra-articular bullet injuries in the measures of even 0.5mm intervals.