Detection of Orthopaedic Implants In-vivo by Walk-Through Metal Detectors

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INTRODUCTION

Since September 11, 2001, airports in the United States and across the world have heightened their security standards in an effort to discourage terrorism. As a result, orthopaedic patients who have metallic implants frequently ask their surgeons if they need a physician's note to travel. In response to this concern, the American Academy of Orthopaedic Surgeons issued a statement in 2001 informing physicians that due to higher levels of security, orthopaedic surgeons should consider writing notes for patients with metal implants. With no specific guidelines or studies showing which implants or metals set off airport detectors, orthopedic surgeons have had limited information available to identify which patients must be warned about their implants causing problems during air travel.

The Transportation Safety Administration's (TSA) official statement regarding medical implants is that all individuals with medical implants that set off the detector will be patted down as an extra screening procedure. Individuals who carry an identification card signed by a physician can bypass the metal detector and receive a brief personal screening.[1] At present time, there is no definitive evidence as to which types of metal implants can set off detectors under the current security guidelines.

Early studies showed that orthopedic implants had a relatively small detection rate. In 1992, Pearson et. al[5] showed that most orthopedic implants such as plates, and screws, as well as total hip and knee replacements, were not picked up by metal detectors. In their study, only the Austin Moore straight fenestrated endoprosthesis set off a detector. In 1994, Rhijn et al[6] concluded that airport detectors, as a rule, do not detect metal implants.

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Other studies have shown that metal implants are readily identified by airport detectors. In 1997, Grochs et. Al[3] found that metal detectors were able to pick up all implants heavier than 195g. Basu et, al[2] looked at the ability of an implant to set off metal detectors at low and high security levels, both in-vivo and strapped to a healthy volunteer. This study concluded that only Richards cannulated screws, Austin-Moore prostheses, and more than three replacements in one patient can set off metal detectors. In a study from London, Kamineni et. al[4] found that in-vivo, total knee and hip replacements were readily detected, while shoulder and ankle arthroplasties were not detected. They found no correlation between BMI and the likelihood of detection.

At the time of this study, no trials have been performed in the United States under the new national security guidelines. Our goal is to look at the ability of orthopaedic implants to set off airport detectors. We believe that with the new guidelines, there should be an increase in the number of implants detected by airport detectors than previously reported. The results of this study will not only aid the surgeon in identifying which patients may require a card to take with them on their travels, but hopefully aid the security agencies in identifying which medical devices set off metal detectors.

MATERIALS AND METHODS

This study was carried out during clinic hours at the Department of Orthopaedic Surgery at the Beth Israel Deaconess Medical Center over a time period of one month. Patients with all types of orthopaedic implants were invited to participate in this study. Patients with pacemakers and those unable to ambulate without assistive devices were excluded.

Patients were asked to remove any metal-containing objects from their body or clothing, including watches, earrings, belts and shoes. Once all metallic objects were removed, patients were asked to walk though the metal detector a total of two times. A positive result was recorded as a buzzer sound in any of the individual trials.

Metal Detection

All patients walked through an M-Scope® 3 zone metal Detector (Fisher Labs, Los Banos, California). The M-scope detector is one of the metal detectors currently being used by TSA at airports all across the United States.

Detector was set at two sensitivity settings, one being the equivalent of Transportation Security Administration sensitivity at low security, and the second, the equivalent of TSA increased security standard.

RESULTS

A total of 129 patients with 149 implants participated in this study [Figure 1]. Approximately one half of implants were trauma hardware - intramedullary nails, plates, screws and K-wires - and the other half were arthroplasties and spine fusion hardware.

One half of the implants were detected by the metal detector at any setting. Three-fifths of patients with multiple implants set off the metal detector at low security versus two-fifths with single implants. Multivariate analysis revealed that the type of implant, material composition, and body location were all independent predictors of detection.

In terms of the type of implants, arthroplasties were found to be detected much more readily than plates, being detected 9/10 times versus 3/10 times for plates. Screws were only detected 1/5 times, while K-wires and nails were not detected [Figure 2].

We found a significant difference in the detection rates of the different materials. All cobalt-chromium implants were detected, while only 3/5 of titanium, and 1/4 of stainless steel implants were detected [Figure 3]. Compared to stainless steel, titanium (Ti) was five times more likely to be detected, while cobalt-chromium (CoCr) was 73 times more likely.

All of the total hips analyzed were detected. Nine of ten of the total knee replacements were detected. There was a significant difference in the overall detection rates based on location of implants. Approximately 2/3 of lower extremity implants were detected compared to only 1/5 of upper extremity and 1/6 of spine implants [Figure 4]. Lower extremity implants were ten times more likely to be detected than upper extremity and eleven times more likely than spinal implants.

DISCUSSION

Since 9/11, patients have become increasingly worried about potential inconveniences at airport security checks brought about by their orthopaedic implants. Orthopaedic surgeons have had few studies on which to base their counseling of patients with these concerns. Previous studies looking at this issue have been published outside of the United States and were performed before September 11, 2001.

The data presented shows that orthopaedic implants, as a whole, are more likely to be detected than previously reported. Over 90% of total knee replacements and 100% of total hip replacements in this study were detected, regardless of whether they were unilateral or bilateral. This result is significantly different than that of Pearson et al[5] who reported that only the Austin-Moore prosthesis was detected by airport detectors, and also different Ghrohs et al[3] who reported that only large prostheses weighing more than 195g could be detected.

In this study, we found that the metallic composition of the implant was an independent predictor of detection. Stainless steel was detected less often than titanium and cobalt-chromium. This pattern was consistent between the different types of implants, with stainless steel plates detected less than titanium plates and stainless steel arthroplasties detected less than titanium arthroplasties. Cobalt-chromium seems to be the most widely detected material, but this was only found in total knee arthroplasties. Since none of the plates or screws analyzed in this study were made out of CoCr, it is not possible to comment as to their ability to set off detectors in other parts of the body.

Location of implants is an independent predictor of detection. Upper extremity implants were less likely to be detected than lower extremity implants regardless of type and material composition. The same is true for spine hardware which was detected less readily than lower extremity hardware, independent of type and material. Due to the small sample size of this study, it was not possible to discern the factors that account for this difference.

CONCLUSIONS

1. Total hip and knee arthroplasties, as a rule, can be expected to be identified by airport detectors.
2. One-third of plates and one-fifth of screws are expected to be detected. K-wires and nails were not detected.
3. Titanium implants are five times more likely to be detected than stainless steel.
4. Two-thirds of lower extremity implants were detected. Lower extremity implants are ten times more likely to be detected than upper extremity.

FUTURE DIRECTIONS

Further studies are under way looking at the variety of factors that may account for the differences seen in this study. More specifically, we would like to know what factors account for the difference in detection rates in different body locations.

Ex-vivo studies are in progress to look at a variety of different implants and determine the ability of these implants to be detected outside of the body. The results of this study will provide us with a baseline of what implants are able to be detected and allow us to work backward in assessing what factors in-vivo account for these implants being detected or not.

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