Original Article

Detection of Orthopedics Implants in Vivo by Hand-Held Metal Detectors

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Objective: To assess rates of detection of various orthopedic implants by airport detectors with the new security sensitivities.

Materials and Methods: Two hundred sixty-one volunteers with 386 implants were asked to be scanned by a hand-metal detector model Garrett SUPER SCANNER™. The sensitivity was set equivalent to the Suvarnabhumi Airport Transportation Security Administration setting for regular security.

Results: Of the 386 implants in 261 patients who were screened, 231 (60%) were trauma hardware, including intramedullary nails, plates, screws, and Kirschner wires, and 155 (40%) were arthroplasty implants. Three hundred thirty-five (86.78%) of the 386 implants were detected by the metal detector. The overall rate of detection was 99.35% for prosthetic replacements and 98.05% for plates. All the total knee replacements and 95% of the total hip replacements were detected. The Kirschner wires were not detected. The overall detection rate was 92.54% for implants in the lower extremity, 55.73% for those in the upper extremity, and 93.33% for those in the spine. The detection rate for implants in the lower extremity was two times higher than the implants in the upper extremity and equal for implants in the spine.

Conclusion: Most of the orthopedic implants may be detected by hand-metal detector model metal detector used at commercial airports. Total joint prostheses, nails, and plates will routinely set off the detector, whereas screws and wires are rarely detected. Cobalt-chromium and titanium implants are more likely to be detected than stainless-steel implants.

Keywords: Orthopedic Implant, Hand-Held Metal Detector, Security

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Since September 11, 2001, airports in the United States and across the world have heightened their security standards in efforts to discourage terrorist attacks[1]. Patients with metallic orthopedic implants have become increasingly concerned about these implants setting off detectors. They often ask if they require a physician's note for air travel. Orthopedic surgeons have had limited data available to identify which patients must be warned about their implants causing delays during air travel. In response to this concern, the American Academy of Orthopedic Surgeons issued a statement in 2001 informing physicians that, as a result of higher levels of security, orthopedic surgeons should consider writing notes for patients with metal implants[2]. The Transportation Security Administration (TSA)'s official statement regarding medical implants is that all individuals with such 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 move directly to the individual screening[3]. The goal of the present study was to assess the ability of metal detectors to detect various common orthopedic implants. The results will not only aid surgeons in counseling patients regarding their implants but also aid security agencies by identifying which medical devices commonly set off metal detectors.

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Objective

The purpose of the present study was to assess

rates of detection of various orthopedic implants by the airport detector with the new security sensitivities.

Materials and Methods

The present study was approved by the Institutional Review Board. Patients with all types of orthopedic implants were invited to participate. Prior to the enrollment, informed consent was obtained, and a brief history was elicited. All patients with a cardiac pacemaker and those with other metallic implants were excluded. After being asked to remove any metallic objects from their body or clothing, including watches, earrings, belts, shoes, and mobile phones, they were scanned by hand-held metal detector. If the alarm sounded during scanning, the result was considered positive.

All patients were scanned by hand-metal detector model Garrett SUPER SCANNER™, which is one of the metal detectors currently being used by the Transportation Security Administration (TSA) at Suvarnabhumi Airport. The detector settings were obtained from the manufacturer engineers, familiar with detector settings at TSA laboratories, as the TSA does not post their detector settings for security reasons. Operative notes for each patient were reviewed to determine the location and type of the implant, which were cross-referenced with the patient's radiographs. No new radiographs were made as part of the present study. The metallurgic composition of the implant was obtained directly from published specifications or direct contact with the manufacturer.

Statistical analysis

Implants were grouped according to type, location, and material composition. Miguel A. Report that 52% of the 149 orthopedic implants were detected by the walk-through metal detector[4] with a defined type I error 0.05. The sample size was 384. Descriptive statistics was used for analysis. The results were presented as frequency and percentage. The data were analyzed with SPSS Statistics for Windows, version 15.0 (SPSS Inc., Chicago, IL, USA).

Results

Of the 386 implants in 261 patients who were screened, 231 (60%) were trauma hardware, including intramedullary nails, plates, screws, and Kirschner wires, and 155 (40%) were arthroplasty implants (Table 1).

Three hundred thirty-five (87%) of the 386 implants were detected by the metal detector. The overall rate of detection was 99% for prosthetic replacements compared with 98% for plates. All the total knee replacements and 95% of the total hip replacements were detected. The Kirschner wires were not detected. The overall detection rate was 92% for implants in the lower extremity, 56% for those in the upper extremity, and 93% for those in the spine. The detection rate for implants in the lower extremity was two times higher than that in the upper extremity, and equal for implants in the spine.

Table 1. Numbers of orthopedic implants that were detected by the metal detector

	n
Wire at neck	0/1
Hook plate at shoulder	1/1
Plate human	9/9
Lumbar instrument (ROD)	25/25
Lumbar instrument (plate)	3/4
Fore arm plate	24/24
Fore arm screw	0/4
Hand K-wire	0/23
Total hip arthroplasty	19/20
Hemiarthroplasty	19/19
PFNA	5/5
DHS	7/7
Multiple screw at hip	1/6
Nail femer	23/24
Plate femer	29/29
Total knee replacement	116/116
Screw at knee	2/2
Tibial nail	7/7
Tibial plate	26/26
Foot K-wire	3/9
Screw at foot	7/15
Plate at foot	3/3

Almost of the knee and hip prostheses were detected. The detection rate was considerably equal for the prostheses as for the plates. One hundred one (98%) plates were detected.

The nine patients with screws did set off the alarm (33%). Only one of the 28 Kirschner wires did set off the alarm. There was a significant difference in the detection rates among the different materials (Figure 1). Cobalt-chromium implants were detected in 82 of 83 (99%). Of the 154 titanium implants, 151 (98%) were detected, compared with 102 (68%) of the 149 stainless-steel implants. Compared with

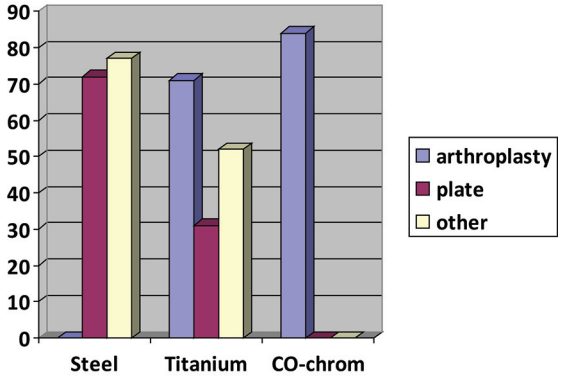

Figure 1. The metallic composition of the implant that were detected by the metal detector.

stainless steel, cobalt-chromium was two times more likely to be detected, and titanium was also likely to be detected.

Overall, the detection rates varied according to the extremity in which the implant was situated. The total detection rate at extremities were 272 (92%) of the 293 lower-extremity implants, compared with 33 of the 63 upper-extremity implants (56%), and 28 (93%) of the 30 spine implants. The likelihood of detection was two times higher for the lower-extremity implants than for the upper-extremity implants and the same for the spine implants.

Discussion

The present study documents that orthopedic implants are more likely to be detected than previously reported. Ninety-five percent of the total hip replacements and 100% of the total knee replacements in the present study were detected, regardless of whether they were unilateral or bilateral. The authors observed that the metallic composition of the implant was an independent predictor of detection. Cobalt-chromium and titanium implants were detected more often than those made of stainless steel. Cobalt-chromium seems to be the most detected material, but it was found only in total knee and total hip prostheses. Since none of the plates or screws analyzed in the present study were made of cobalt-chromium, it is not possible to comment on its ability to set off detectors when it is situated in other parts of the body.

The location of the implant is another independent predictor of detection. Upper-extremity and spine implants were less likely to be detected than those of the lower-extremity implants, regardless of the type or material composition. The greater size and weight of implants in the lower extremities may account for this difference. Upper extremities were more likely to have a single implant, such as a distal radial plate, and those single implants were smaller and of lower profile than those in the lower extremities.

The increased in detector sensitivity is comparable with what is expected when security at airports was changed from standard to high, as may occur during holidays, busy travel seasons, times of war, or high terrorist threat.

There were several limitations to the present study. Although the present sample size was adequate to provide a diverse group of implants and the numbers allowed to generalize among different types of implants, a much larger cohort of patients is required to critically evaluate each implant individually.

The present study was also limited to an assessment of the sensitivity of one specific detector. Even though the sensitivity settings were comparable with the airport settings, different detectors may have different detection rates. Finally, the sensitivity of a metal detector, according to the manufacturer, can be influenced by local magnetic interference, such as those coming from fluorescent lighting or medical imaging devices.

Repeating the study in different locations may show a difference in detection rates. Based on data from the present study, the authors can make the following observations regarding orthopedic implants and airport hand-held metal detectors: 1) total hip and knee prostheses can be expected to be identified by airport hand-held detectors, 2) Kirschner wires and screw are unlikely to be detected, 3) lower-extremity implants are much more likely to be detected than upper-extremity and spine implants, and 4) cobalt-chromium and titanium implants are much more likely to be detected than stainless steel. These observations can aid surgeons in advising patients with orthopedic implants who are concerned about metal detection at airport security points.

Since September 11, 2001, patients have become increasingly worried about their orthopedic implants potentially causing inconveniences at airport security checkpoints. Only a few investigators have provided data to counsel patients regarding these concerns. Previous studies of this issue were published outside of the United States and were performed before September 11, 2001.

Initial studies demonstrated a general insensitivity of airport detectors to metal implants. In 1992, Pearson and Matthews[5] found that most orthopedic implants, such as plates and screws as well as total hip

and knee replacements, were not identified by metal detectors. Only the Austin-Moore straight fenestrated endoprosthesis set off a detector. In 1994, van Rhijn and Veraart[6] concluded that airport detectors, as a rule, did not detect metal implants. More recent studies have documented that airport detectors can be set off by specific orthopedic implants. In 1997, Grohs and Gottsauner-Wolf[7] found that the detectors identified all implants heavier than 195 g. Basu et al[8] studied the ability of an implant to set off metal detectors at low and high-security settings both in vivo and when strapped to a healthy volunteer. They concluded that only cannulated hip screws, Austin-Moore prostheses, and more than three joint replacements in one patient set off metal detectors. In a study from London, Kamineni et al[9] found that in vivo total knee and hip replacements were readily detected, while shoulder and ankle prostheses were not detected. They found no correlation between body mass index and the likelihood of detection.

Conclusion

Most of the orthopedic implants may be detected by hand-metal detector model metal detector used at commercial airports. Total joint prostheses, nails, and plates will routinely set off the detector, whereas screws, and wires are rarely detected. Cobalt-chromium and titanium implants are more likely to be detected than stainless-steel implants.

What is already known on this topic?

In 1997, Grohs and Gottsauner-Wolf[7] found that the detectors identified all implants heavier than 195 g. Basu et al[8] studied the ability of an implant to set off metal detectors at low and high-security settings both in vivo and when strapped to a healthy volunteer. They concluded that only cannulated hip screws, Austin-Moore prostheses, and more than three joint replacements in one patient set off metal detectors. In a study from London, Kamineni et al[9] found that in vivo total knee and hip replacements were readily detected, while shoulder and ankle prostheses were not detected. They found no correlation between body mass index and the likelihood of detection.

What this study adds?

This study documents that orthopedic implants are more likely to be detected than the previously reported. Ninety-five percent of total hip replacements and 100% of total knee replacements were detected, regardless of whether they were unilateral or bilateral. The metallic composition of the implant was an independent predictor of detection. Cobalt-chromium and titanium implants were detected more often than those of stainless steel. Cobalt-chromium seems to be the most detected found only in total knee and total hip prostheses. Since none of the plates or screws in this study were made of cobalt-chromium, it is not possible to comment on its ability to set off detectors when situated in other parts of the body.

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Conflicts of interest

The authors declare no conflict of interest.

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