DETECTION OF ORTHOPAEDIC PROSTHESES AT AIRPORT SECURITY CHECKS

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We studied the detection of joint replacements at airport security checks in relation to their weight, using two types of detector arch. A single-source, unilateral detector showed different sensitivities for implants on different sides of a test subject.

All implants weighing more than 145 g were detected by one of the arches. The degree of detection was directly related to the logarithm of the weight of the prosthesis in patients, with a linear correlation ($r^2 = 0.61$). A bilateral arch detected all prostheses weighing over 195 g.

With their usual sensitivity settings many joint replacements were detectable; an identification pass containing the site and weight of such prostheses would help to avoid the need for body-search procedures.

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Patients with implanted joint prostheses often ask whether these will produce problems with security checks at airports. Each year at Vienna International Airport, many thousands of passengers have re-examinations by hand-held detectors and body checks because of positive results at detection arches. Body checks on patients with orthopaedic implants are often necessary because electronic devices cannot distinguish between these and other metallic sources.

There have been previous reports on the detection of braces and implants used in the management of trauma. These suggest that screws, plates, intramedullary nails and single joint replacements go undetected, but that large or bilateral joint implants of stainless steel or weighing over 400 g give positive results.

In our department, most hip replacements are of a titanium (Ti) or cobalt-chromium-molybdenum (Co-Cr-Mo) alloy, and weigh much less than 400 g. Despite this many of our patients experienced activation of metal detector arches and the need for individual body searches. Most problems were reported from the airports of Vienna, Paris and Antalya (Turkey).

We have therefore studied the detection of orthopaedic joint replacements in relation to their weight at an international airport with modern security equipment.

PATIENTS AND METHODS

Metal detection. At Vienna International Airport passengers walk through metal detector arches after handing over loose metal items such as keys, etc. A positive result leads to the location of the metal by hand-held detectors, and when necessary body searches.

Metals are detected by changes in a magnetic field caused by horizontal movement. Two different types of detector arch were tested.

Detector one (Heimann MDT8900, Wiesbaden, Germany, 1989 model) had one sender and one receiver panel; levels of detection were indicated by 24 luminous diodes. Passengers activating more than five of these require individual examination.

Detector two (CEIA 02PN8A, Costruzioni Elettroniche Industriali Automatismi, Arezzo, Italy, 1994 model) has several magnetic coils giving a uniform magnetic field, and also has a software filter which can discriminate between different metals by Fourier transformation. Every positive alarm leads to individual searches.

Both detectors are calibrated according to the directions of the Austrian Ministry of the Interior: no changes are allowed. This sensitivity setting exceeds the minimum limits of the Federal Aviation Administration (USA).

Study design. In the first part of the study different implants were taped to a volunteer who walked through the arch at constant speed and in both directions. Femoral stems of titanium-aluminium-niobium (Ti-Al-Nb) alloy (Alloclassic; Allopro, Winterthur, Switzerland) in sizes 3 to 11 and weighing 125 to 300 g, and implants of vitallium (Co-Cr-Mo alloy) (Howmedica Modular Resection System-
endoprostheses; Howmedica Inc, Limerick, Ireland) weighing 250 to 2060 g, were fixed consecutively at the shoulder, the hip and the knee (Fig. 1).

In the second part of the study 15 patients with joint prostheses walked three times in each direction through each of the detector arches. Eight had unilateral and four bilateral cementless hip implants (Alloclassic, Allopro). Each single implant weighed 145 to 215 g (Ti-Al-Nb), or 270 g (Ti-Al-Nb with a head of Co-Cr-Mo). The bilateral implants had individual weights of 255 to 435 g (Ti-Al-Nb) or 535 g (Ti-Al-Nb with a head of Co-Cr-Mo). Two patients had Duracon knee implants (Howmedica) weighing 430 to 570 g and one had a proximal femoral HMRS implant (Howmedica) weighing 1170 g.

The weight of the metal in the prostheses was determined to the nearest 10 g using an electronic balance and the volume calculated from the specific weight of Ti-Al-Nb (4.6 g/ml) and Co-Cr-Mo (8.5 g/ml). The volume of Co-Cr-Mo alloy implants ranged from 29.4 to 242.4 ml and that of Ti-Al-Nb implants only from 27.2 to 65.2 ml.

Correlations between the level of detection and the weight of the prostheses were calculated for the side and level of the implants and the direction of passing through the detector arches. Correlations between the level of detection and the volume of the implants were calculated for each alloy. All calculations were performed using Fig P software (Biosoft, Cambridge, UK).

RESULTS

Implants fixed to a test subject showed different results at the two detector arches. At arch one (Heimann MDT8900) detection depended on the weight of the implants, but also varied with the side of the body. We found a linear correlation between the degree of detection and the logarithm of the weight both for prostheses nearer the receiver panel \((y = 14.3(\log x) – 24.9; \ r^2 = 0.96, n = 30)\) and for those nearer the sender panel \((y = 13.7(\log x) – 29.2; \ r^2 = 0.89, n = 27)\). Detection began at weights of 125 g and 230 g, respectively, which made a difference of six diodes on the detector panel for the same weight on opposite sides. We found no difference between the implants at shoulder, hip or knee level.

There was also a linear correlation between detection and volume for implants of Ti-Al-Nb \((y = 0.2 \times -4.5; \ r^2 = 0.98, n = 30)\) and of Co-Cr-Mo \((y = 0.1 \times +7.1; \ r^2 = 0.94, n = 30)\). This difference was caused by a higher sensitivity for small implants of Co-Cr-Mo alloy with volumes beneath 40 ml.

At detector two (CEIA 02PN8A) all implants weighing more than 200 g were detected independently of side and location. The degree of detection depended only on weight.

Patients with joint replacements also showed weight-dependent detection of implants at detector one (Fig. 2, upper panel); there was a linear correlation with the logarithm of the weight \((y = 6.4(\log x) – 8.2; \ r^2 = 0.61, n = 90)\). All implants of over 145 g were detected, on either side of the body. Only the lightest implants failed to trigger the alarm (Fig. 3). The threshold of detection intensity which would lead to further examination was calculated to be 165 g.

At detector two all implants with weights higher than 195 g were detected (Fig. 2, lower panel). Only knee implants (two patients 430 and 570 g) and small bilateral
hip implants (two patients, together 255 to 310 g) failed to trigger the alarm in 61% of attempts.

DISCUSSION

Our study was designed to relate the detection of orthopaedic prostheses to their weight and volume.

At Vienna International Airport, many small- and medium-sized joint replacements were being regularly detected, contrary to previous reports. Implants such as plates and gamma nails with weights up to 250 g had not been detectable. The differences are partly due to the side of fixation of the implants in the non-uniform magnetic field of detector one. Another factor is probably a different sensitivity setting for non-iron metals; this can vary between different airports. Modern joint implants contain little iron or are made of stainless steel and are thus non-magnetic. The detection of the large HMRS implant is in accordance with that of all other studies.

Prostheses fixed to a test subject were detected more easily than implanted prostheses, possibly due to the masking effect of tissue coverage.

The detection of knee implants and bilateral hip implants was lower (39%) in the newer detector two than in detector one, possibly because of the filter technique used in detector two, or the relatively small volume of the knee implants.

Modern orthopaedic replacements for the hip, knee and shoulder have weights from 133 g up to nearly 3000 g for segmental prostheses. All except the lightest will be detected at the sensitivity settings at Vienna airport; this is apparently necessary to detect some modern weapons which may contain only a small amount of iron. A security check using a detector arch and a hand-held detector for localisation would distinguish orthopaedic implants and other metal sources, if an identification pass giving site and weight were provided. This would avoid the need for body searching.

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REFERENCES


Fig. 3

Percentage of prostheses causing an alarm for each type of detector, related to weight: 145 to 190 g represents small hip prostheses (Allopro up to stem size 5), 191 to 400 g large hip or small knee prostheses and 401 to 1100 g large knee or tumour resection prostheses (Duracon knee large, HMRS). Individual search would be needed for hatched groups.