Title: Variation in pelvic radiography practice: why can we not standardise image acquisition techniques?

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Background

Radiographs remain an essential part of patient assessment in musculoskeletal care and, in particular, for the management of osteoarthritis (OA).[1] Although their use in the initial diagnosis and monitoring of OA has been questioned,[2,3] they remain the standard tool for investigation of symptom progression across a range of anatomical areas despite their limitated sensitivity.[1] One key role is in the pre-operative planning and post-operative surveillance for joint replacement surgery, not least in the hip. As comparison of successive examinations is standard in arthroplasty assessment it is critical that the image acquisition parameters and examination quality remains consistent.[4-6]

Despite the centrality of radiographs to clinical decision making, the impact of acquisition techniques on interpretive accuracy, surgical planning or treatment success is poorly understood. A range of factors involved in radiographic practices have the potential to affect diagnostic and/or measurement accuracy and it is important that these are acknowledged by referrers, radiographers and those professionals responsible for interpreting the resultant images (Box 1).

Box 1: Implications for different image acquisition parameters on radiographic appearance and decision making

There have been demands for standardisation of pelvis radiographic studies[4,6] and some authors have even proposed acquisition protocols.[7,8] Despite this there is no evidence that these have been adopted by diagnostic imaging centres. This article reports on a study to identify whether there is standardisation of pelvis radiograph acquisition parameters in the United Kingdom (UK), and identify

explore any variation in practices. It focuses on non-trauma examinations of the pelvis and hip and forms part of a larger study, Mapping the Evolution of Technique in Orthopaedic Radiography (METeOR).

Method

This was a cross-sectional survey of UK NHS diagnostic imaging departments utilising an electronic tool (Bristol Online Survey®, Bristol, UK). Following a review of the literature, the survey comprised both closed and open questions relating to the local protocol for radiographic examination of the non-trauma pelvis (questionnaire available from the authors). Respondents were asked to provide information with respect to imaging of adults referred from outpatients (OP) or general practitioner (GP), including patient position, centring point, source image receptor distance (SID), patient orientation (supine, erect) and the use of calibration (templating) devices. Where appropriate, respondents were able to provide additional free text information. An initial pilot study was conducted using a cohort of five experienced radiographers which resulted in minor amendments to the questions on specific acquisition parameters to aid comprehension.

The survey invitation was distributed as a hard copy letter to the imaging managers of all UK NHS Trusts (or Health Boards) identified from Government statistics and national hospitals databases (n=182). The invitation asked for the survey information to be distributed to the individual responsible for the radiographic imaging protocols. The invitation included a short web address to the online tool and the survey remained open for 12 weeks, with a reminder letter distributed 4 weeks before the closing date. Prospective participants were provided a contact email address for a member of the study team if there was any uncertainty about the questions or survey scope. To ensure accurate response analysis, invitees were asked to complete the survey only once and organisational name was sought to ensure no duplicate responses were received.

The survey collected anonymised data, as this was an evaluation of current practice ethical approval was not required following completion of the Health Research Authority (HRA) checklist. However, ethical issues were considered following discussions with the local Research and Development department and the study adhered to good research practice guidance. Consent was implied on completion of the survey and this was outlined in the participant information provided in the invitation letter. Data from the electronic survey were downloaded into Excel (Microsoft, US) and a password protected de-identified version was used for analysis.

Results

Responses were received from 69 sites within the specified timeframe, a response rate of 37.9%.

Profile of respondents

In relation to geographic spread and self-selected hospital type the majority were from English district general hospitals (DGH).

Table 1: Survey responses by country and organisation type

At the time of the survey the majority of sites had a mixture of computed radiography (CR) and direct digital radiography (DR) equipment (n=60/69; 87.0%), with only a small number using a single technology (CR only n = 5; DR only n=4).

Image acquisition protocols

There were inconsistencies in SID, from 90 to 115cms (Table 2), with three sites not able to prvide a definitive number but rather identifying a range. The evolution of technology from CR to DR appeared not to be influencing technique.

Table 2: Variation in source image-receptor distance (SID)

Almost all hospitals perform their non-trauma pelvis radiographs supine, with only a single teaching hospital (n=1/69; 1.4%) confirming that their routine protocol required the examination to be performed erect. In relation to leg position, the feet are usually internally rotated (n=65/69; 94.2%), with the remaining four sites describing a 'neutral' position.

There were numerous centring points described, including seven respondents who did not describe a specific location, but rather stated that the "*iliac crests would be included at the top"*. This was exacerbated by description of additional projections such as *'AP [antero-posterior] pelvis for hips'* and one respondent saying that "*Orthopaedic [referrers] require centering for hips since invariably they will have THR [total hip replacement]. To include prosthesis*".

Table 3: Described local centring point for pelvis radiographs

A number of respondents reported that a lateral hip projection is often performed in addition to the pelvis, although there appeared to be no consistency in the criteria used. Many confirmed this was dependent on the clinical history such as: "*ortho have HBL [horizontal beam lateral] hip prior to THR*" and "*lat [lateral] hip if hip joint clinical history*"; whereas others suggested it was dependent on the referrer (individually or speciality): "*turned lateral for orthopaedic referrals*", "*for orthopaedic referrals we also perform either a turned lateral or HBL lateral of the affected hip*."

Calibration device use

Orthopaedic calibration devices were not in routine use, with only 21 using them on pelvic radiographs (30.4%). There was further inconsistency evident with some using such devices only on specific clinic or consultant referrals, for example "*we only use ortho [orthopaedic] templating tool at ortho consultant request*" and "*template ball used for 1 ortho consultant*". Although the type of device was not sought, one respondent described "*using a 2p piece at the minute*".

Discussion

Pelvis radiography remains a commonly performed procedure in radiology departments[9] and the resultant images underpin clinical management decisions across numerous specialities. The positioning for pelvic radiographs has remained relatively unchanged for the last 100 years, but this study found that there is inconsistent practice across the UK. The results also confirm the findings of a previous pan-European survey by McFadden.[10] This outcome is critical, as radiographic diagnosis relies on the identification of often subtle changes which may be masked by variations in anatomical morphology as a result of patient positioning.[11,12] However in addition to the differences in radiographer practice, referrals also appear to conflicting, both in terms of projections and anatomical inclusion.

Most radiography technique texts[13-16] cite similar acquisition parameters, with the patient lying supine and their feet internally rotated 15-20^0 (where stated), with the centring point described as in the midline, midway between the symphysis pubis and the anterior superior iliac spines (ASIS). With the exception of SID, the orthopaedic literature is in broad agreement, although centring remains a

debated topic, with Lim and Park[8] citing the same position, whilst others suggest the centre point should be just above the symphysis.[7,11] The confusion between 'pelvis' and 'hip' radiographs may explain some of this variation with the low-centred pelvis commonly being performed for planning and/or follow up of hip arthroplasties. Importantly, imaging field and centre point can impact on how anatomy is demonstrated as beam geometry can influence anatomical representation, of particular relevance when version of the acetabulum (native or arthroplasty) is being evaluated. This has been challenged by Goldman and Hoover[9] who, following a cadaverous experiment, suggest that centring point and SID do not affect key hip morphology measures. This may provide some assurance, and further, Plaugher et al[17] found that consistency in position could be achieved between operators. However their study was conducted in a chiropractic, rather than diagnostic imaging setting and as a result thay may have found less individual (radiographer) and organisational (hospital) variation.

Additional positional considerations in the diagnosis of pelvic morphology are highlighted by some radiography texts which suggest that slight knee flexion, with or without the aid of a pillow, will improve patient comfort.[18,19] The hip flexion resulting from such a position will certainly alter the orientation of the proximal femur and will alter the pelvic tilt (incidence). The other key variation in limb position is internal rotation of the leg to correct for femoral neck anteversion.[20] This also forces the femoral head into the acetabulum as a result of muscular pressure[21,22] and is considered to mimic weightbearing.[23] It is also perhaps important to note that no radiography textbook describes the procedure for weightbearing (standing) pelvis radiography despite many authors advocating this technique.[24-26] Although some do suggest the value of this technique is not yet proven and further research is required.[3,27,28]

The distance of the tube from the patient and imaging receptor, the SID, previously referred to as focus film distance (FFD), will alter anatomical magnification due to the divergent beam. Historically acetate films were used for arthroplasty templating but digital technology has standardised practice. The accurate planning for surgical implants does however require knowledge of the magnification factor, either by use of a calibration device or fixed distance. The latter has found favour amongst some,[29,30] but relies on a standard approach being adopted by equipment manufacturers and imaging departments. It may be possible this can be managed at a local level, but the transfer of patients (and/or images) between hospital sites does not guarantee that a standard SID has been employed. Conversely, calibration devices may allow more accurate results,[31] but these must be applied consistently and accurately.[27,31-33]

The number of research studies where images have been excluded due to poor quality reinforces the variation in practice.[20,34-38] Quality criteria for pelvis radiographs are often poorly articulated, even in research studies, however some[35,36,39] refer to the sacro-coccygeal distance established by Siebenrock et al,[40] where a measure of excessive anterior or posterior pelvic tilt is used as a proxy for quality. This does raise other issues, as despite limits for neutral tilt being suggested,[38] this does not acknowledge any natural anatomical variations between patients, but rather is considered a failure of good radiographic positioning. It is unclear how many of these excluded radiographs would have been considered diagnostic and accepted in clinical practice as quality criteria are likely not to be agreed or applied at a local level, either between referrers or imaging departments.

Limitations

This study had a number of limitations. Firstly, the response rate was disappointing and this must be acknowledged in any attempt to generalise the study outcomes. Secondly, radiographic positioning described may also vary at an individual radiographer level as protocols may not state the actual centring or distance and therefore the results likely reflect the acquisition techniques of the individual completing the survey. As a result, the results will describe the minimum (rather than maximum) variation in practice.

Conclusion and recommendations

Despite calls for consistency in pelvis and hip radiography techniques there appears to be ongoing variation across most acquisition parameters in the UK. Standardisation and the establishment of specific quality outcome measures are required to provide confidence during image interpretation particularly with respect to serial radiographs.

Parctitioners should be aware of the implications of different image acquisition protocols and understand the techniques utilised by their local departments. This does require, and provide opportunities for, increased clinical and research collaboration between the orthopaedic speciality and imaging departments.

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