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Variability of magnification on digital pelvic radiographs from patients with fractures of the femoral neck - a retrospective audit

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ORIGINAL ARTICLE

Variability of magnification on digital pelvic radiographs from patients with fractures of the femoral neck — a retrospective audit

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Abstract

Objective: To determine the variability in magnification of radiographs in an emergency setting.

Methods: The retrospective study was conducted at Aga Khan University Hospital, Karachi, and comprised records of patients who underwent Austin Moore hemiarthroplasty over a two-year periodfrom 1st January 2006 to 31st December 2007. Magnification factor was determined using measurements obtained from preoperative and postoperative radiographs and comparing them with the actual size of implant used. Intra-observer and inter-observer reliability of measurements were calculated. SPSS 19 was used for data analysis.

Results: Of the 63 patients studied, 25(39.7%) were males and 38(60.3%) were females with an overall mean age of 69.8±12 years. The mean implant size used was 46mm±4mm. Preoperative magnification was 8%±4%, resulting in an overestimation of implant size by 4.2±2.3mm. Postoperative magnification was 13%±4%, resulting in an overestimation of 5.9±1.9mm.Prediction using fixed scaling of 15% resulted in a correct estimation of implant size for only 15(24%) patients.

Conclusion: Digital radiographs of the pelvis exhibited variable amount of magnification along with an inconsistency in magnification on repeat examination.

Keywords: Total hip replacement, Femoralneck fractures, Radiographic magnification. (JPMA 64: S-158 (Suppl. 2); 2014)

Introduction

Preoperative planning enables the surgeon to think three-dimensionally, improves the precision of surgery, shortens the length of the procedure and reduces the incidence of complications.[1,2] It also provides the surgeon with a tool to ascertain the availability of correct prosthetic component sizes. This helps reduce the burden on hospitals to maintain all available implant sizes in stock at all times.[3]

Variation in magnification factor of radiographs is a major challenge during preoperative planning of total hip arthroplasty (THA) surgery. Inability to judge the exact position of the hip joint is the primary reason for this error. Even though digital softwares have made templating easy, their accuracy is also affected by this variation.[3,4]

Several methods to predict magnification and scale radiographs have been studied and reported in literature. Most of them require either placement of radio-opaque markers of known dimensions adjacent to the patient during radiography, or use of mathematical formulas considering weight of the patient for predicting magnification.[5-7]

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THA is becoming a common treatment approach for displaced neck of femur fractures and its advantages are fast outweighing those of hemiarthroplasty in the fit and ambulant elderly.[8,9] Radiographs obtained in the emergency setting on such patients may not be the most optimal for templating compared to those acquired in the elective setting. Furthermore, the techniques employed for accounting for magnification in the elective setting may not be applicable in this scenario. This may add to the difficulty in predicting the magnification of radiographs and may adversely affect the accuracy of templating.

The current study was planned to determine the magnification factor of preoperative pelvic radiographs in patients who had displaced neck of femur fractures. Moreover, the difference in magnification between the preoperative and postoperative radiographs of the same person was also studied to see the variation brought in by performing radiographs in the emergency setting. Improved understanding of this variation in magnification is expected to enable the surgeon to consider such variability while templating and selecting the implant size during preoperative planning.

Materials and Methods

The retrospective study was conducted at Aga Khan University Hospital, Karachi, and comprised records of patients who underwent Austin Moore hemiarthroplasty over a two-year period from 1st January 2006 to 31st

December 2007. Patients who did not have preoperative and/or postoperative radiographs available on the digital radiograph archive were excluded.

Since Austin Moore hemiarthroplasty is done more frequently at the study site compared to THA, thus the former was chosen. Also, this is the same population in which THA may be offered and the need for templating may arise.

Magnification of the preoperative radiographs was determined by dividing the difference between the size of the femoral head, as measured on the preoperative radiograph, and the size of the actual implant used, by the actual size of implant used, and expressing it as a percentage.

Preoperative Magnification =

$$\frac{\text{(Femoral head - actual size of implant)}}{\text{Actual size of implant used}} \times 100\%$$

Similarly, magnification of postoperative radiographs was determined by dividing the difference between the size of implant, as measured on the postoperative radiograph, and the actual implant size, as recorded in hospital inventory, by the actual size of implant used, and expressing it as a percentage.

Postoperative Magnification =

$$\frac{\text{(Size of implant on X-ray-Actual size of implant)}}{\text{Actual size of implant used}} \times 100\%$$

Intra-observer reliability was tested by repeating measurements on five preoperative and five postoperative radiographs picked at random by the same observer at different times, blinded to the previous measurement. Inter-observer reliability was tested by comparing measurements on five preoperative and five postoperative radiographs performed by two different observers. The observer taking measurements from the radiographs was blinded to the actual implant size used.

Pearson's correlation coefficient was used for statistical evaluation of the intra- and inter-observer reliability with a significance level set at $p<0.05$.

Spearman's correlation and Student's t test was used to study the effect of age and gender on magnification. Analysis was performed on SPSS 19.

Results

Medical record of 73 patients were identified initially, but 10(13.7%) did not meet the inclusion criteria. The remaining 63(86.3%) patients formed the study sample; 25(39.7%) males and 38(60.3%) females with an overall mean age of 69.8±12 years. The mean implant size used was 46mm±4mm (range: 38-57mm).

Intra-observer and inter-observer reliability was comparable ($p=0.994$ and $p=0.982$ respectively). Preoperative magnification was 8%±4% (range: 1-16%), resulting in an overestimation of implant size by 4.2±2.3mm (range: 0.5-10mm). Postoperative magnification was 13%±4% (range: 6-25%), resulting in an overestimation of 5.9±1.9mm (range: 2-10mm).

The mean discrepancy in preoperative and postoperative values was 1.9±2.7mm (range: 4.3-7.6mm) ($p=0.012$).

No significant relationship was found between gender and magnification or between age and magnification factor ($p>0.05$ each).

Prediction using fixed scaling of 15% as is used in most templates resulted in a mean underestimation of implant size by 3.2±1.85mm (range: 0-7mm). This resulted in a correct estimation of implant size for 15(24%) patients and within 2 implant sizes for 23(36%), and >2 implant sizes in the remaining 25(40%) patients.

Discussion

Although it is well known that magnification in radiographs is subject to variation, but there is no consensus on which method is the most accurate in predicting magnification. Several methods have been reported to accurately predict the magnification of a radiograph, most have made use of a calibration marker of known dimension at the level of the hip joint either medially or laterally. Some have used callipers to measure known pelvic dimensions and compare them with measurements on the radiograph, whereas others have derived formulas based on the weight of the patient.[5-7] Though helpful in the elective setting, the usefulness of these methods in an emergency setting seems limited.

King et al.[10] reported significant magnification of radiographs performed on trauma patients in the emergency setting with substantial variability among the different body areas. They reported a magnification of 22% (13-29%) for the femoral head, which is considerably higher than the 8% (-16%) observed in the current study.

Brew et al.[11] suggested calculating the mean magnification of one's own radiology department and using it as a factor to scale radiographs. But even so, in this study, the mean magnification in the emergency setting was substantially different from the standard (postoperative) magnification of the radiology department (8±4% vs. 13±4%). This difference in the magnification of preoperative and postoperative

radiographs of the same patient suggests that factors other than patient-related ones are at play in the emergency setting.

Our study also reveals that up to 40% of patients may have miscalculation of implant size (>2 sizes from the expected) for which a large inventory needs to be available. This miscalculation may result in inconvenience if the requirement of a previously unanticipated odd size arises in the operating room during surgery.

Conclusion

The surgeon should be aware of the variability in magnification of radiographs, especially when they are acquired in the emergency setting. Templating performed on these radiographs may not be accurate and appropriate inventory should be available to avoid intra-operative inconvenience.

References

1. Blackley HR, Howell GE, Rorabeck CH. Planning and management of the difficult primary hip replacement: preoperative planning and technical considerations. Instr CourseLect. 2000;49:3-11.
2. Eggli S, Pisan M, Muller ME. The valueof preoperative planning for total hip arthroplasty. J Bone Joint Surg Br. 1998;80:382-90.
3. White SP, Shardlow DL. Effect of introduction of digital radiographic techniques on pre-operative templating in orthopaedic practice. Ann R Coll Surg Engl. 2005 ;87:53-4.
4. Gamble P, de Beer J, Petruccelli D, Winemaker M. The accuracy of digital templating in uncemented total hip arthroplasty. J Arthroplasty. 2010;25:529-32.
5. Descamps S, Livesey C, Learmonth ID. Determination of digitised radiograph magnification factors for pre-operative templating in hip prosthesis surgery. Skeletal Radiol. 2010;39:273-7.
6. Franken M, Grimm B, Heyligers I. A comparison of four systems for calibration when templating for total hip replacement with digital radiography. J Bone Joint Surg Br. 2010;92:136-41.
7. Wimsey S, Pickard R, Shaw G. Accurate scaling of digital radiographs of the pelvis. A prospective trial of two methods. J Bone Joint Surg Br. 2006;88:1508-12.
8. Liao L, Zhao J, Su W, Ding X, Chen L, Luo S. A meta-analysis of total hip arthroplasty and hemiarthroplasty outcomes for displaced femoral neck fractures. Arch Orthop Trauma Surg. 2012;132:1021-9.
9. Yu L, Wang Y, Chen J. Total hip arthroplasty versus hemiarthroplasty for displaced femoral neck fractures: meta-analysis of randomized trials. Clin Orthop Relat Res. 2012;470:2235-43.
10. King RJ, Craig PR, Boreham BG, Majeed MA, Moran CG. The magnification of digital radiographs in the trauma patient: implications for templating. Injury. 2009;40:173-6.
11. Brew CJ, Simpson PM, Whitehouse SL, Donnelly W, Crawford RW, Hubble MJ. Scaling digital radiographs for templating in total hip arthroplasty using conventional acetate templates independent of calibration markers. J Arthroplasty. 2012;27:643-7.