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The value of contrast and subtraction arthrography in the assessment of aseptic loosening of total hip prostheses: A meta-analysis

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Abstract

Objective: To summarize and compare the diagnostic accuracy of contrast and subtraction arthrography in the assessment of aseptic loosening of total hip arthroplasties.
Design: This meta-analysis was performed using methods described by the Cochrane Methods Group on Systematic Reviews of Screening and Diagnostic Tests. We included original, English-language papers published between January 1975 to October 2004 that examined contrast-enhanced arthrography with or without subtraction for diagnosis of loosening of total hip prostheses. A qualitative and quantitative analysis was performed by two investigators.
Results: With regard to the acetabular component, pooled sensitivity and specificity for contrast arthrography was 70% (95% confidence interval, 52–84) and 74% (95% CI, 53–87), respectively. Subtraction arthrography had a significantly higher sensitivity of 89% (95% CI, 84–93) ($p = 0.01$), with a similar specificity of 76% (95% CI, 68-82). For the femoral component, pooled sensitivity and specificity for contrast arthrography were 63% (95% CI, 53–72) and 78% (95% CI, 68–86). Pooled estimates for subtraction arthrography revealed a significantly higher sensitivity of 86% (95% CI, 74–93) ($p = 0.003$). Specificity was 85% (95% CI, 77–91) and was similar to the data of contrast arthrography ($p = 0.23$).
Conclusion: Using the present data we found that the subtraction arthrography is a sensitive technique for detection of loosening of total hip prostheses, offering added value over contrast arthrography, especially for evaluation of the femoral component.

Keywords: Hip; Prostheses; Arthrography; Subtraction; Digital

1. Introduction

Contrast enhanced arthrography is a frequently applied diagnostic modality used for the detection of hip prosthesis loosening. Since its introduction, this technique was improved by the introduction of subtraction arthrography, and digital subtraction arthrography [1,2]. In a study by Warner et al., a potential benefit was reported for digital subtraction arthrography compared to contrast arthrography [3]. However, randomized or prospective comparisons of contrast and subtraction arthrography were not performed. The objective of this meta-analysis was to assess the diagnostic accuracy of contrast enhanced arthrography in the patients suspected of a aseptic loosened total hip prostheses, and to meta-analytically compare the arthrographic techniques currently used in clinical practice.

2. Materials and methods

2.1. Study identification

We attempted to identify all studies that examined contrast-enhanced arthrography with or without subtraction

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for diagnosis of loosening of total hip prostheses. In order to identify all relevant literature, we developed a computerized search strategy for locating studies published between January 1975 and October 2004 in the PUBMED and EMBASE databases. We included original, English-language, full-length, human-adult studies, and made no attempt to include unpublished data.

2.2. Study eligibility

Screening and selection of potentially relevant studies for inclusion was performed independently by two investigators (O.T. and P.R.). The reviewers were not blinded to the journal, authors, institutional affiliation, or date of publication. We included studies that (1) examined the diagnostic performance of contrast-enhanced arthrography in patients suspected of aseptic loosening of a total hip prosthesis; (2) included at least 10 patients (3) used surgery, or a clinical follow-up of at least one year as gold standards; (4) reported the data in sufficient detail to calculate a contingency tables and the index test characteristics, (5) reported sufficient detail to categorize studies as subtraction arthrography or contrast arthrography. In case of disagreement, a consensus was reached by repeated reviewing, and discussion.

2.3. Study quality

A quality assessment of eligible studies was performed using a modified version of the checklist designed by the Cochrane Methods Group on Systematic Review of Screening and Diagnostic Tests. The criteria cover two dimensions: internal validity, used to assess methodological quality of studies, and external validity which is used for key characteristics of included studies (e.g. scanning protocols, interpretation criteria). Our checklist included assessment of the following aspects; (1) application of a standardized and valid reference test, performed independently of the index test; (2) the presence of verification bias; (3) study design and research planning (e.g. a retrospective or prospective study design); (4) the source of the patient population(e.g. primary care or secondary care); (5) patient characteristics (e.g. age, sex); (6) description of eligibility criteria; (7) key characteristics of the applied index test. Eligible studies were subsequently categorized to their validity of evidence as described by the Centre for Evidence-Based Medicine of the National Health Service Research and Development (http://www.cebm.net/levels_of_evidence.asp). This framework features five levels of evidence with four corresponding levels of evidence. Level 1 corresponds with level A grade of recommendation, and includes studies performed in an independent and blinded fashion describing an appropriate patient population. Level 4 describes none blinded studies and corresponds with a grade C level of recommendation. Quality assessment was performed independently by two reviewers (O.T. and P.R.). During the quality assessment, the reviewers were not blinded for the authors or publication sources. In case of disagreement, consensus was reached by discussion.

2.4. Data analysis

Before calculation of a pooled estimates of contrast-enhanced arthrography, heterogeneity was assessed using methods described by Midgette et al. [4]. Heterogeneity of the sensitivity and specificity was tested using the Chi-square test or the Fisher's exact test with k-1 degrees of freedom (k: number of studies). The Spearman's rank correlation coefficient ρ was used in order to measure the extent of correlation between sensitivity and specificity. In case ρ was >-0.4, we performed a subgroup analysis and used a univariate meta-regression analysis to evaluate the influence of prosthesis characteristics, and the internal and external validity criteria, on the diagnostic accuracy. A ρ value <-0.40, suggests that the variation between studies may be explained by different cut-off points on a Summary Receiver Operating Characteristic (SROC) curve. A SROC curve represents the optimum operating point of a test, and is constructed by fitting a regression line through the sensitivity, and 1-specificity combinations of each study. Similar to conventional ROC curves, a curve closer to the left upper quadrant indicates better diagnostic performance of this particular imaging technique. A detailed description regarding methods for fitting the curve is illustrated in the study by Littenberg and Moses [5]. In order to detect outlier studies, we construct a Galbraith plot [6]. This plot is constructed by plotting the natural logarithm of the diagnostic odds ratio (DOR) on the y-axis against the inverse of the standard error on the x-axis. Studies outside the 95% boundaries were considered as outliers. We used the data and formula as described by Fleiss to measure the extent of heterogeneity of the DOR [7]. In case of remaining heterogeneity between studies a random effect model was chosen. Finally, pooled estimates of sensitivity and specificity of contrast and subtraction arthrography were compared with a Z-test. A p-value <0.05 was considered as significant.

3. Results

3.1. Included studies

We identified sixty-four potentially relevant studies that had been published since 1975. After title, and abstract selection, thirty full text articles were selected presenting sufficient data for quantitative analysis [3,8–36]. Twenty-four studies described contrast-enhanced arthrography in the acetabular component [3,8–10,12,13,16,18–23,25–33,35,36], eight studies were performed using contrast arthrography [9,18,23,25,28,29,32,33], and ten studies reported the use of subtraction arthrography [3,8,12,13,16,20,21,30,31,36]. Six studies describing the acetabular component did not specify their data with regard to the arthrographic technique