Journal of Orthopaedics 15 (2018) 442–446

Contents lists available at ScienceDirect

Journal of Orthopaedics

journal homepage: www.elsevier.com/locate/jor

Review Article

Leg length correction in computer assisted primary total hip arthroplasty: A collective review of the literature

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ARTICLE INFO

Keywords:
Computer assisted surgery
Computer navigated surgery
Total hip arthroplasty
Leg length correction
Leg length discrepancy

ABSTRACT

Aim: The aim of this study was to determine whether computer assisted surgery (CAS) can provide a more accurate, reproducible technique to achieve equal leg lengths in total hip arthroplasty (THA) and to compare the clinical outcome with conventional on table judgement of leg lengths in unilateral total hip replacement.
Methods: A collective review of the literature was undertaken utilizing applicable databases. Research criteria were the following: (1) Developing and developed country studies, (2) level II, III, IV and V studies, (3) human subjects only, (4) period of study from 1996 to 2017 - English text only. The identified publications were assessed for their relevance and methodology and 20 articles were selected.
Results: The overall evaluation of the results demonstrates that CAS provides a more accurate reproduction of limb length in THA compared to conventional freehand THA. Short to medium-term studies have demonstrated no benefit in clinical outcome scores. There is a high degree of correlation between measurements provided by CAS intraoperatively and radiographic measurements postoperatively.
Conclusion: CAS provides a more accurate, reproducible technique to achieve limb length equality in THA compared to conventional freehand THA, however more intensive long-term studies are required to establish the effect on implant longevity and revision surgery rates in the two groups.

1. Introduction

The burden of degenerative hip disease in our population has increased dramatically in recent years and total hip arthroplasty (THA) is one of the most successful orthopaedic procedures performed to alleviate pain, improve motion and increase patient quality of life. Leg length discrepancy (LLD) is a common cause of patient dissatisfaction following total hip arthroplasty (THA) and one of the leading causes of litigation in orthopaedic practice.[1] A LLD of less than 1 cm is generally well tolerated and in order to achieve this consistently, one needs to be familiar with the various surgical techniques and the accuracy of each one in clinical practice. Achieving equal leg lengths is often dependent on a careful preoperative assessment of the patient, and utilizing a reproducible technique to translate the preoperative plan into a good clinical result. Many techniques are described in the literature, and computer assisted surgery (CAS) is one of the more novel approaches which has piqued interest in orthopaedic hip arthroplasty in recent years.

The main objectives of THA are pain relief, hip stability and mobility, equal leg lengths and implant longevity. Implant longevity is directly related to the accuracy of positioning of the various components during surgery and the reproduction of normal hip biomechanics to prevent excessive wear of the implant. CAS is currently not utilized in mainstream orthopaedic practice due to the high initial setup costs and the increased surgical time required. In addition, it has a steep learning curve, and requires that the surgeon is familiar with the freehand technique in the event of computer malfunction.[2,3]

A collective review of the literature was performed to determine whether CAS provides a more accurate reproduction of limb length equality compared with conventional freehand technique and whether this has an impact on clinical outcome scores in the short to medium-term.

2. Materials and methods

A collective review of the literature was undertaken utilizing applicable databases viz. ClinicalKey, OVID, Pubmed and Springer Link. Research criteria were the following: (1) Developing and developed country studies, (2) level II, III, IV and V studies, (3) human subjects only, (4) period of study from 1996 to 2017 - English text only. The

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https://doi.org/10.1016/j.jor.2018.03.032
Received 11 December 2017; Accepted 25 March 2018
Available online 27 March 2018

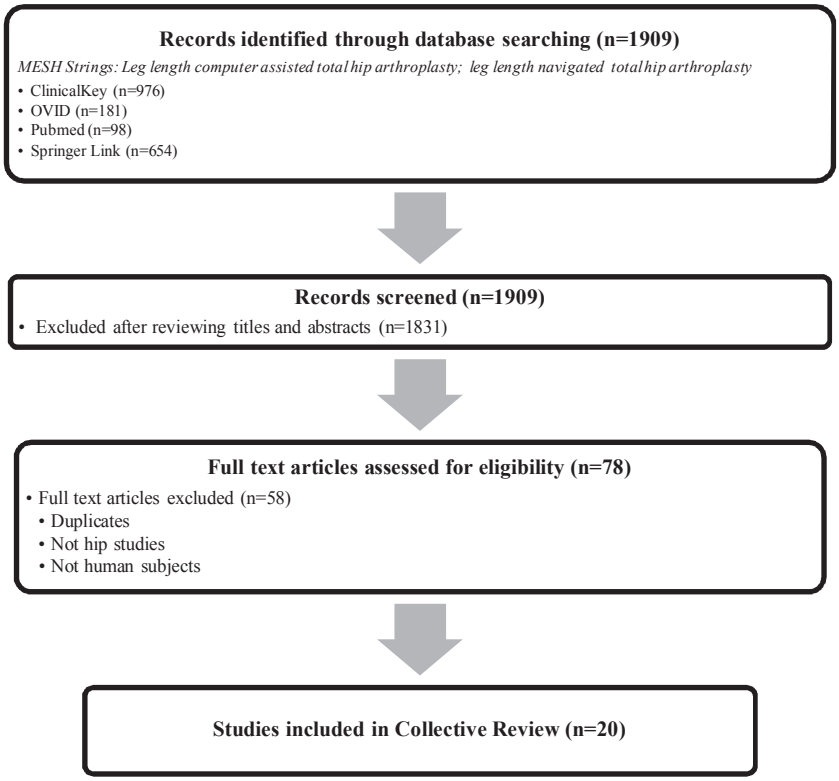

Fig. 1. Flow chart of the study selection and inclusion process.

search strategy is presented below (Fig. 1).

The following Medical Subject Heading (MeSH) terms were used: "Leg length computer assisted total hip arthroplasty"; "Leg length navigated total hip arthroplasty". 1909 Search results were obtained, which identified 79 relevant publications. The identified publications were assessed for their relevance and methodology and 20 articles were selected. Published literature of level II, III, IV and V human studies were included from the year 1996 to 2017. The contents of featured articles were appraised qualitatively with regards to CAS used as well as quantitatively regarding limb lengths achieved and clinical outcomes using standardized scoring systems.

3. Workflow to achieve equal leg lengths using CAS

According to Wasterlain et al.[4] CAS has the potential to improve the accuracy and reproducibility of implant positioning in THA. CAS can be performed using two different techniques viz. imageless and image-based (CT, MRI or intra-operative Fluoroscopy). These systems register anatomical landmarks with sensors that are placed on the patient intraoperatively to translate the patient data onto a 3D computer model which is displayed on a high definition computer monitor. CT-based systems allow visualization of a patient-specific model whereas imageless systems rely on a generic simulated model.[4]

The first step in the registration process is to define the anterior pelvic plane, by attaching an optical tracking array (*static reference frame)* to the patient's iliac crest, usually with a Steinmann pin. The femoral reference plane is determined by probing anatomical landmarks such as the greater trochanter, patella and femoral condyles. The accuracy of the navigation system relies on the surgeons ability to accurately define these planes.[2,4,5] To calculate the 3D relationship between the implants and the patient's anatomy, the surgeon controls instruments which have an optical tracking array attached to them *(dynamic reference frames)*. The interaction between the *static reference frame*, and the *dynamic reference frames* is what allows the surgeon to adjust the leg length, femoral offset, inclination angle and anteversion of the cup with dynamic live values displayed on a computer monitor.[2,4] The definition of outliers varies in the literature from a LLD $>$ 5 mm to a LLD $>$ 10 mm.[6–11]

4. Results

4.1. CAS versus conventional freehand technique

Data was extracted from 14 studies and a synopsis is presented in Table 1. Manzotti et al. performed a matched-pair study and assessed the clinical outcome using the Harris Hip Score (HHS) and Western Ontario and McMaster Universities (WOMAC) Arthritis Index.[7] The post-operative LLD in the CAS group was significantly lower and had fewer outliers (10.42%) compared to the freehand group (27.08%).[7] Their short term follow up (minimum of 6 months), revealed no statistically significant difference in clinical outcome scores and they advocated a longer follow-up.[7]

A retrospective study by Licini et al. found at a minimum follow-up of 1 year, that CAS was able to restore the leg length more accurately with fewer outliers than the non-navigated group.[12] However, this did not translate into a better clinical score (HHS) and the perception of LLD was not diminished in the CAS group.[12] They also recommended longer follow-up.

In a prospective randomized study by Lass et al., significant improvement in the HHS and WOMAC index was noted in both groups and no significant difference was found at a minimum follow-up of 1.5 years.[13] The authors also investigated the angles of inclination and anteversion of the acetabular component and found significantly more accurate anteversion angles in the navigated group.[13] Accurate placement of the acetabular cup using CAS is in keeping with other studies analyzed in a meta-analysis by Xu et al. and aids in the restoration of leg length.[9]

Brown et al. found no difference in accuracy of components, leg length and clinical outcome(HHS) in their series of patients comparing CAS to freehand technique.[14] Their main drawbacks for CAS were