Evidence Review

ALBERTA BONE & JOINT HEALTH INSTITUTE

Topic: Clinical effectiveness of mini-incision total hip arthroplasty

Introduction

There is considerable interest and debate over the use of minimally-invasive techniques in total hip arthroplasty (THA). Currently, THA is among the most successful surgeries performed today, with predictably excellent and reproducible results. [1] Yet despite this, the objectives of minimal surgical trauma, reduced intraoperative blood loss, quicker surgery, reduced pain, faster recovery and smaller scars have driven the development of less invasive options to the traditional standard approach to THA. Although less-invasive THA performed through a minimal incision is regarded as a new investigational technique by most surgeons, there is growing interest among health care providers and the public over this approach to total hip replacement surgery. Marketing of the new technique has encompassed many hospital and physician websites which corroborate manufacturers' advertising campaigns of less postoperative pain and faster recovery. The intent of this evidence review is to objectively assess the efficacy and safety of mini-incision THA compared to standard THA based on the best available evidence.

Total hip arthroplasty

THA is the surgical replacement of a severely diseased or fractured hip joint with an artificial joint. The main indications for this procedure are significant pain and disability of the hip associated with osteoarthritis, rheumatoid arthritis, avascular necrosis, traumatic arthritis or hip fractures. [2] The goal of a total hip replacement is to provide the patient with a pain-free, well-fixed, stable arthroplasty that restores function and survives for many years [3] and the long term results of this operation, with survival rates of up to 95% after 10 years and up to 90% after 20 years [4], are well documented.

In THA, the implant consists of three parts: a ball to replace the femoral head, a stem which is inserted into the femur, and a cup that is inserted into the acetabulum of the pelvis. The standard surgical approach of this operation is often through an incision of 20-25cm in length. [5,6] Most orthopaedic surgeons prefer a posterior or anterolateral approach to the hip joint, [5,6] although other approaches such as the anterior, direct lateral (transgluteal) and lateral transtrochanteric [7] are also used. The incision is of sufficient length to permit complete and continuous viewing of the entire hip joint and periarticular structures. The drawbacks of such a large incision include significant soft tissue disruption, pain and lengthy rehabilitation time. [8] The Canadian Institute for Health Information (CIHI) reported that nearly 22,000 hip replacements were performed in Canada in fiscal 2002, and this number is expected to increase with the aging population. The introduction of surgical techniques that reduce the length of hospitalization, complication rates, and speed up patient recovery following THA could reduce health care costs associated with total hip replacements.

Less-invasive total hip arthroplasty

Ideally, surgical intervention should be optimized to give the best results while minimizing potential complications and hastening recovery. The use of minimally invasive techniques in other surgical fields has made these goals achievable. For example, fast recovery times, lower postoperative morbidity rates, and reduced costs have been achieved with laparoscopic gall-bladder and hernia surgery. [3,9] Minimally invasive techniques have also facilitated improvements in the orthopaedic field. Examples include arthroscopic meniscetomy, arthroscopic subacromial decompression, arthroscopic rotator cuff repairs, endoscopic ACL reconstruction, and microdiscectomy, among others. [10]

Since the late 1990s, surgeons have been developing and promoting two different forms of less-invasive techniques for THA. One method is to operate through a single mini-incision (generally defined as ≤ 10 cm) or two very small incisions (one 2 cm, the other up to 6 cm) to perform the same THA performed in the standard approach procedure. [11] This evidence review will focus on the outcomes of the single mini-invasive THA.

Limited incision less-invasive THA refers to a group of procedures performed through a minimal incision, generally defined as 6 - 10cm in length and often with the use of specialized instruments, with the aim of limiting soft tissue dissection during the insertion of a hip replacement. [11] The potential advantages of a less invasive, minimal-incision THA compared with standard techniques include accelerated recovery, decreased surgical time, decreased blood loss, less pain, shorter hospitalization, lower risk of complications, and cosmetic appeal. [5,10]

Minimally-invasive or Less-invasive THA?

A review of the literature shows conflicting terminology used in the description of the procedures used to perform THA through a minimal incision. Such techniques are often described as 'minimally-invasive' or 'less-invasive'. Although the incision lengths and positions, surgical approaches to the hip, and the extent of soft dissection may vary among the various mini-incision THA procedures, the underlying goal of these procedures is to minimize the disruption of muscles and periarticular soft tissue. Some authors argue that total hip replacement surgery, even with careful attention given to limiting soft tissue disruption, is not minimally-invasive by its very nature, but that the surgical process can be performed less invasively. [3,12,13] Duncan et al (2006) [3] have noted that the operation, regardless of the technique used, requires the surgeon to expose the hip, excise the femoral head, ream the acetabulum, and insert two relatively large implants, and that this inherently invasive surgery almost always requires hospitalization and is associated with substantial morbidity. Woolson (2006) [11] also noted the invalid comparison between minimal-incision THA and minimally-invasive orthopaedic procedures such as arthroscopic menisectomy. For example, that author notes that the later procedure does not involve the placement of a large prosthesis within the body but involves the removal of relatively small portions of soft tissue from the open anatomic space of the knee joint, and this procedure is almost always performed on an outpatient basis. For the purposes of this evidence review, THA procedures performed through a minimal incision approach will be referred to as less-invasive THA.

Aim of review

The aim of this evidence review is to assess the evidence in the literature towards the clinical efficacy and safety of less-invasive THA compared to the standard approach THA.

Review Design

Search Strategy

The objective of this evidence review was to assess the outcomes of less-invasive primary THA with respect to effectiveness, safety and cost-effectiveness, in comparison to standard incision approach THA. To ensure that studies of good scientific quality were selected, preference was given for systematic reviews and randomized controlled trials. However, all types of comparative studies could be included in this review. Non-comparative studies, such as case series, case studies, and expert opinions, are regarded as having the lowest level of evidence [14] and were excluded in this review.

Searches of the major medical electronic databases (Cochrane DSR, Ovid MEDLINE, PubMed, EMBASE, CINAHL) were conducted with the following search strategy:

> Search Term: (mini OR minimal OR micro OR small OR limited OR short OR abridged) AND (approach OR incision OR exposure OR invasive) AND (arthroplasty OR replacement) AND (hip) AND English[la]

Study inclusion criteria

The selection criteria for published studies were as follows:

- Comparative studies that assess outcomes (efficacy, safety, cost-effectiveness) of minimal-incision less-invasive THA vs. standard-approach THA
- Studies based on primary THA patients
- Studies wherein the primary diagnosis is OA
- Studies limited to English-language reporting

Exclusion criteria included:

- Non-comparative studies (e.g., case series, case report) on less-invasive THA
- Studies that do not contain patient data
- Studies that report on hip replacement prostheses that are not conventional total hip replacement devices (e.g., hip

resurfacing devices)

- Studies that compare multi-incision THA to single-incision less-invasive THA or standard approach THA

Studies selected for inclusion:

- Ogonda et al. 2005. [15] A minimal-incision technique in total hip arthroplasty does not improve early postoperative outcomes. A prospective, randomized, controlled trial. J Bone Joint Surg Am.87(4):701-10
- Chimento et al. 2005. [16] Minimally invasive total hip arthroplasty: a prospective randomized study. J Arthroplasty. 20(2):139-44
- Wenz et a. 2002. [5] Mini-incision total hip arthroplasty: a comparative assessment of perioperative outcomes. Orthopedics.25(10):1031-43
- DiGioia et al. 2003. [17] Mini-incision technique for total hip arthroplasty with navigation. J Arthroplasty. 18 (2):123-8
- Higuchi et al. 2003. [18] Minimally invasive uncemented total hip arthroplasty through an anterolateral approach with a shorter skin incision. J Orthop Sci. 8(6):812-7
- de Beer et al. [19] 2004. Single-incision, minimally invasive total hip arthroplasty: length doesn't matter. J Arthroplasty.19(8):945-50
- Wright et al. [10] 2004. Mini-incision for total hip arthroplasty: a prospective, controlled investigation with 5-year follow-up evaluation. J Arthroplasty. 19(5):538-45
- Chung et al. 2004. [1] Mini-incision total hip replacement--surgical technique and early results. J Orthop Surg (Hong Kong).12(1):19-24
- Woolson et al. 2004. [11] Comparison of primary total hip replacements performed with a standard incision or a mini-incision. J Bone Joint Surg Am. 86-A(7):1353-8
- Nakamura et al. 2004. [20] Mini-incision posterior approach for total hip arthroplasty. Int Orthop. 28(4):214-7
- Howell et al. 2004. [21] Minimally invasive versus standard incision anterolateral hip replacement: a comparative study. Orthop Clin North Am. 35(2):153-62
- O'Brien et al. 2005. [22] The mini-incision direct lateral approach in primary total hip arthroplasty. Clin Orthop Relat Res. 441:99-103
- Szendroi et al. 2006. [23] The impact of minimally invasive total hip arthroplasty on the standard procedure. Int Orthop. 30(3):167-71
- Khan et al. 2006. [13] Less invasive total hip arthroplasty: description of a new technique. J Arthroplasty. 21 (7):1038-46

Studies excluded but of interest:

- Ciminiello et al. Total hip arthroplasty: is small incision better? J Arthroplasty. 21(4):484-8. [Note: small incision group exposure length defined only as < 12.7cm.]
- Hartzband. 2004. Posterolateral minimal incision for total hip replacement: technique and early results. Orthop Clin North Am. 35(2):119-29. [Case series report]
- Jerosch J et al. 2006. Antero-lateral minimal invasive (ALMI) approach for total hip arthroplasty technique and early results. Arch Orthop Trauma Surg. 126(3):164-73. [Case series report]
- Floren M ET AL. 2006. Durability of Implant Fixation After Less-Invasive Total Hip Arthroplasty. Journal of Arthroplasty. Vol. 21(6): 783-90. [Mean incision size not specified]
- Dorr LD. 2004. The mini-incision hip: Building a ship in a bottle. Orthopedics. 27: 192-194. [unable to attain report]
- Swanson TV. 2005. Early results of 1000 consecutive, posterior, single-incision minimally invasive surgery total hip arthroplasties. Journal of Arthroplasty. 20(7 Suppl 3): 26-32. [Case series report]

Quality control

The quality of the two selected randomized controlled trials (RCT; Ogonda et al. 2005 and Chimento et al. 2005) was assessed by an independent reviewer. Study quality was measured using a validated scale [24] developed by the Cochrane Collaboration Back Review Group. With this assessment tool, evaluation of an RCT is based on study design, randomization, blinding, data collection and statistical analysis procedures that minimize biases. Both studies were judged to have high quality.

Results

Description of Randomized Controlled Trials

A brief summary of the RCTs included in this trial are provided in tables 1 and 2.

Table 1: Description of mini-incision THA RCTs

Study	Study Type	Study period	Groups	Incision Size (range)	Number of hips	Surgical Approach	Mean Patient Age (range)	Mean BMI kg/m^2 (range)
Ogonda et al. 2005	RCT	2003-2004	MINI	9.2 ± 0.4cm	109 (109 patients)	Posterior	67.4 ± 9.8	28.2 ± 4.3
			STND	16.0 ± 0cm	110 (110 patients)	Posterior	65.9 ± 10.3	28.9 ± 4.3
Chimento et al. 2005	RCT	1999-2000	MINI	8cm	28 (28 patients)	Posteolateral	67.2 ± 8.6	25.2 ± 3.1
			STND	15cm	32 (32 patients)	Posteolateral	65.6 ± 10.5	24.8 ± 2.5

Data are mean ± SD, unless otherwise indicated. MINI: mini-incision, STND: Standard incision.

Table 2: Perioperative results of mini-incision THA RCTs

Study	Groups	Incision Size (range)	Operating Time (range)	Intra-operative Blood Loss (range)	LOS (range)	Complications	Study Follow-up Period (range)
Ogonda et al. 2005	MINI	9.21 ± 0.44cm	60.3 ± 9.2min	314 ± 162mL*	3.65 days (2-13)	MINI (n=109) 1 Deep wound infection 1 Superficial wound infection 1 Dislocation	6 weeks
	STND	16.00 ± 0.00cm	65.9 ± 13.2min	366 ± 190mL*	3.68 days (2-22)	STND (n=110) 2 Intraoperative fractures 1 Dislocation 1 Deep vein thrombosis	
Chimento et al. 2005	MINI	8 cm	70.3 ± 10.7min	127 ± 48mL*	5.8 days (4-13)	MINI (n=28) 2 Dislocations (1 required revision) 1 Cardiac problems 1 Visual hallucinations from narcotic 1 Sciatic pain on contralateral leg	2 years
	STND	15 cm	70.0 ± 8.5min	170 ± 65mL*	5.5 days (3-15)	STND (n=32) 1 Developed rash 1 Analgesic-related confusion	

Data are mean ± SD, unless otherwise indicated. MINI: mini-incision, STND: Standard incision.

Ogonda et al. (2005) were the first to report a prospective, randomized blinded trail of less invasive THA. In this study, 219 primary total hip replacements were performed between 2003 and 2004. Patients were randomized to receive THA through a minimal incision (n=109) or a standard incision (n=110). All patients were blinded to the size of their incision throughout their hospital stay. Anesthetic, analgesic, and post-surgery rehabilitation protocols were standardized, and staff were blinded to the incision size used. Preoperatively, both groups were similar in age, BMI, functional scores (Harris hip score, WOMAC, Oxford hip score), SF-12 scores and comorbidity level (as inferred from ASA grades). Furthermore, the main indication for THA in both groups was osteoarthritis. The mean operative time was similar for both groups, although the authors noted that the mean operative time was significantly increased for patients in both groups with a BMI > 35 compared to patients with BMI < 30. The increase in operative time was independent of incision size. Blood loss was significantly more in the standard incision group, although no difference was detected in postoperative transfusion rate, and hematocrit levels at 8 hours and at discharge. This study used a large spectrum of outcome measures. Comparison of clinical preoperative and postoperative outcome measures between the groups is summarized in table 3.

Table 3. Summary of Clinical Measures Comparisons in Ogonda et al.

Test	Mini-incision Group	Standard-incision Group	Statistical Significance
Preoperative			
Harris hip score	29.04 ± 11.65	27.41 ± 13.23	p = 0.34
WOMAC	26.92 ± 11.82	26.23 ± 14.29	p = 0.70
Oxford hip score	49.37 ± 5.04	50.14 ± 5.64	p = 0.29
SF-12 Physical component score	26.18 ± 5.39	26.14 ± 5.40	p = 0.95
SF-12 Mental component score	43.31 ± 12.78	41.96 ± 11.85	p = 0.41
Postoperative (6 weeks follow-up)			
Harris hip score	84.15 ± 10.56	83.36 ± 8.33	p = 0.54
WOMAC	74.40 ± 13.88	73.95 ± 12.90	p = 0.81
Oxford hip score	24.97 ± 7.33	25.88 ± 6.29	p = 0.33
SF-12 Physical component score	38.48 ± 10.20	37.73 ± 9.48	p = 0.58
SF-12 Mental component score	50.61 ± 11.05	51.11 ± 10.54	p = 0.73

Data are mean ± SD. Adapted from Ogonda et al. 2005.

Reduced soft-tissue trauma is a potential benefit of minimally-invasive THA. Inflammatory mediators such as cytokines, including C-reactive protein, respond to trauma. C-reactive protein is know to peak at two days following standard [25], but the rise of the cytokine is significantly reduced when laparoscopic techniques are used compared to open operations in other procedures such as cholecystectomy and hernia repair. [26,27] These authors compared mean serum level of C-reactive protein at 48 hours post-surgery and found no statistical difference between the mini-incision group (135.7 ± 51.2 mg/L) and standard-incision group (125.6 ± 59.4 mg/L). Furthermore, no difference was found in the mean increase in mid-thigh circumference (a measure of postoperative swelling) between the mini-group (4.3 ± 4.2cm) and standard group (3.7 ± 3.9cm). No significant difference was observed between the groups with respect to postoperative pain scores or the volume of morphine used with the patient-controlled analgesia system. No difference was found in mean pain scores in the first seven days following hospital discharge between the groups. The mean length of hospital stay did not differ between the mini-group (3.65 days) and standard group (3.68 days). Finally, postoperative radiographic comparisons found no statistical difference between the groups in terms of component alignments, percentage of outliers, and cement-mantle quality. The authors concluded by stating that "minimally invasive total hip arthroplasty performed through a single-incision posterior approach by a high-volume hip surgeon with extensive experience is a safe and reproducible procedure, but it offers no significant benefit in the early postoperative period compared with a standard incision of 16 cm."

The advantages of this randomized, prospective trial include its adequate sample sizes, use of a single surgeon, same prosthesis implanted in all patients, numerous intraoperative measurements, radiographic analysis and outcome measures. On the other hand, the follow-up period of this study was short.

Chimento et al (2005) conducted a prospective, randomized study that compared outcomes of minimally-invasive THA with the standard approach. Patients were randomized to receive incisions of 8 cm (mini-incision group, n=28) or 15 cm (standard group, n=32). Outcome measures included operative time, length of hospital stay, blood loss, pre- and postoperative complications, pre- and postoperative serum interleukin (IL)-6 levels, radiographic results and functional outcomes (Harris hip score). Consistent treatment to both groups was given by the same surgeon, anesthesiologist and physical therapist. Preoperatively, there was no difference between the groups in terms of age, BMI, and Harris hip scores. Perioperative comparisons between the groups revealed no differences in surgery time, patient-controlled epidural anesthesia, and oral narcotics consumed. Although the mini-incision group had less intraoperative and total blood loss, there was no difference in transfusion requirements. The authors compared changes in serum levels of IL-6, an inflammatory mediator associated with tissue trauma, prior to surgery and at 1 hour post-surgery for both groups. The mini-incision group had an increase of IL-6 levels of 3.79 ± 2.77 pg/mL, compared to the standard group mean level of 3.33 ± 2.80 pg/mL. This difference between the groups was not significant. Furthermore, postoperative radiographic analyses showed no statistical difference between the groups in overall gradings. Harris hip scores were not statistically different at 1 or 2 years postoperatively. In addition to less blood loss, the only other difference observed in this study between the groups was that fewer mini-incision patients (21.4%) had a persistent limp at 6 weeks compared to the standard group (46.8%).

These authors acknowledge a key limitation of this study which is that the low number of patients involved does not provide it with enough power to differentiate complications such as nerve palsy, dislocation, cement technique and position of components. Also, the fixation technique was not consistent as both hybrid and cementless procedures were used.

Description of Observational Studies

Twelve comparative observational studies were included in this review. These studies are summarized in tables 4 and 5.

Table 4: Description of single-incision less-invasive THA Observational Studies

Study	Study Type	Study period	Groups	Incision Size (range)	Number of hips	Surgical Approach	Mean Patient Age (range)	Mean BMI kg/m^2 (range)
Wenz et a. 2002	Case control	1996-2001	MINI STND	7.8cm (5-15) ≥ 25cm	124 (111 patients) 65 (62 patients)	Posterior Lateral	63 (28-91) 65 (21-86)	29 (17-51)* 31 (17-48)*
DiGioia et al. 2003	Case control	NR	MINI STND	11.7cm (7.3-13.0) 20.2cm (14.8-26.0)	35 (33 patients) 35 (33 patients)	Posterior Posterior	65 (49-80) 65 (49-76)	27 28
Higuchi et al. 2003	Case control	1999-2002	MINI MEDM STND	< 10cm 10-15cm >15cm	115 70 27	Anterolateral Anterolateral Anterolateral	~ 64.5 years ~ 62.5 years ~ 61.0 years	~ 22.7* ~ 25.5* † ~ 22.6†
de Beer et al. 2004	Case control	NR	MINI STND	7.7cm (6-10) 13.9cm (11-22)	30 (30 patients) 30 (30 patients)	Lateral Lateral	71.6 (45-86) 69.0 (39-85)	32.4 (21.6-41.7) 31.7 (19.6-43.4)
Wright et al. 2004	Case control	1996-1997	MINI STND	8.8 ± 1.5cm 23 ± 2.1cm	42 (42 patients) 42 (42 patients)	Posterolateral Posterolateral	64.2 ± 15.1 65.0 ± 8.2	24.4 ± 5.7* 28.3 ± 6.1*
Chung et al. 2004	Prospective Cohort	NR	MINI STND	9.2cm (6-11) 20.0cm (15-28)	60 (60 patients) 60 (60 patients)	Posterolateral Posterior	61 (41-83) 64 (48-81)	NR NR
Woolson et al. 2004	Retrospective Cohort	2001-2003	MINI STND	≤ 10cm 15-25cm	50 (50 patients) 85 (85 patients)	Posterior Posterior	60 (20-81) 63 (35-91)	25.1* 28.2*
Nakamura et al. 2004	Case control	2001-2003	MINI STND	10.3cm (9-13) NR (15-20)	50 (48 patients) 42 (39 patients)	Mostly posterior Mostly posterior	62 ± 11 59 ± 10	23.2 ± 3.4 24.0 ± 4.3
Howell et al. 2004	Case control	2002-2003	MINI STND	< 8cm NR	50 (46 patients) 57 (56 patients)	Anterolateral Anterolateral	59.8 ± 11.7 62.3 ± 13.5	26.2 ± 3.7* 28.8 ± 5.8*
O'Brien et al. 2005	Case control	2003-2004	MINI STND	10cm > 10 cm	34 (32 patients) 53 (51 patients)	Lateral Lateral	67 67	27 ± 4 30 ± 9
Szendroi et al. 2006	Prospective Cohort	2003-2004	MINI MEDM STND	8.8 ± 1.0cm 12.6 ± 1.2cm 16.1 ± 1.9cm	38 (38 patients) 43 (43 patients) 21 (21 patients)	Lateral Lateral Lateral	64 ± 12 62 ± 13 57 ± 13	26 ± 3.3* 28 ± 4.2 29.5 ± 7.0*
Khan et al. 2006	Case control	2002	MINI STND	8.4 ± 3.1cm 21.5 ± 3.5cm	100 100	Posterior Posterior	68.9 ± 10.8 69.3 ± 13.3	26.2 ± 5.2 25.4 ± 3.6

Data are mean ± SD, unless otherwise indicated. MINI: mini-incision, MEDM: medium incision, STND: Standard incision. *, † Statistically significant comparison ($p < 0.05$). ~ signifies value approximated from figure. Note: Ogonda et al. and Lawlor et al. reported on different outcomes in the same study population.

Table 5: Perioperative results of single mini-incision THA observation Studies

Study	Groups	Incision Size (range)	Operating Time (range)	Intra-operative Blood Loss (range)	LOS (range)	Complications	Study Follow-up Period (range)
Wenz et al. 2002	MINI STND	7.8cm (5-15) ≥ 25cm	124 ± 37min* 164 ± 45min*	598 ± 325mL* 727 ± 441mL*	3.8 ± 1.5 days 4.0 ± 1.6 days	MINI (n=124) 3 Femoral fractures 2 Neurological injury 4 Hematoma 2 Superficial wound infections 1 Deep wound infection 1 Dislocation STND (n=65) 4 Femoral fractures 1 Neurological injury 2 Superficial wound infections 2 Deep wound infection 1 Deep vein thrombosis	Perioperative outcomes only
DiGioia et al. 2003	MNI STND	11.7cm (7.3-13.0) 20.2cm (14.8-26.0)	120 min 100 min	NR NR	3.8 days 3.9 days	MINI (n=35) 0.7 units of blood transfused STND (n=35) 1.1 units of blood transfused No dislocations or nerve injuries reported in either group.	12 months
Higuchi et al. 2003	MINI MEDM STND	< 10cm 10-15cm >15cm	69.7 ± 15.4min* 77.1 ± 24.3min* 94.9 ± 29.8min*	184.3 ± 120.2g* 250.2 ± 140.0g* 388.2 ± 263.5g*	NR NR NR	MINI (n=115) 1 Fracture 1 Acetabular cup loosening 3 Dislocations MEDM (n=70) 2 Deep vein thromboses 1 Fracture 2 Acetabular cup loosening 1 Dislocation STND (n=27) 1 Acetabular cup loosening 1 Dislocation	NR
de Beer et al. 2004	MNI STND	7.7cm (6-10) 13.9cm (11-22)	46.6min (24-90) 44.5min (17-75)	180ml (100-300)* 247ml (17-75)*	5.13 days (3-8) 5.10 days (4-8)	MINI (n=30) 1 Periprosthetic fracture 1 Cardiac problems STND (n=30) 1 Deep vein thrombosis 1 Hematoma with mild sciatica	6 weeks

Table 5: Perioperative results of single mini-incision THA observation Studies — *continued*

Study	Groups	Incision Size (range)	Operating Time (range)	Intra-operative Blood Loss (range)	LOS (range)	Complications	Study Follow-up Period (range)
Wright et al. 2004	MNI STND	8.8 ± 1.5cm 23 ± 2.1cm	71.4 ± 11.2min* 77.7 ± 13.2min*	151.8 ± 53.9mL 173.2 ± 57.5mL	6.12 days 6.07 days	MINI No complications STND 1 Dislocation	5.08 ± 0.33 years 5.17 ± 0.37 years
Chung et al. 2004	MINI STND	9.2cm (6-11) 20.0cm (15-28)	49min (35-65) 55min (30-90)	136ml (75-250)* 201ml (95-300)*	4.4 days (3-7)* 5.3 days (4-9)*	MINI (n=60) 3 Deep vein thromboses STND (n=60) 5 Deep vein thromboses	14 months (9-26)
Woolson et al. 2004	MNI STND	<= 10cm 15-25cm	97 min 105 min	603mL 507mL	4.3 4.0	MINI (n=50) 2 Femoral fractures 1 Complete sciatic nerve palsy 1 Wound infection 2 Poor wound healing 1 Deep vein thrombosis 1 Atrial flutter 1 Acute cholecystitis STND (n=85) 1 Partial peroneal nerve palsy 1 Dislocation 1 Deep vein thrombosis 1 Prolonged wound drainage 2 Arrhythmias 1 Ileus 1 Perforated diverticulum 1 Pneumonia 1 Hip sublaxation	6 months
Nakamura et al. 2004	MNI STND	10.3cm (9-13) NR (15-20)	99 ± 26min* 123 ± 30min*	339 ± 210mL* 422 ± 177mL*	NR NR	MINI (n=50) 1 Femoral fracture STND (n=42) 1 Surgical debridgement for infection	10 months (6-18) 20 months (6-32)
Howell et al. 2004	MNI STND	< 8cm NR	97 ± 19min* 84 ± 15min*	387 ± 155mL* 469 ± 147mL*	4 ± 1.7 days* 5 ± 1.8 days*	MINI (n=50) 2 Intra-operative fracture 1 Haematoma STND (n=57) 1 Haematoma	Perioperative outcomes only

Table 5: Perioperative results of single mini-incision THA observation Studies — *continued*

Study	Groups	Incision Size (range)	Operating Time (range)	Intra-operative Blood Loss (range)	LOS (range)	Complications	Study Follow-up Period (range)
O'Brien et al. 2005	MINI STND	10cm > 10 cm	74 ± 15min* 80 ± 10 min*	NR NR	5.4 ± 2.1 days* 6.2 ± 2.8 days*	MINI (n=34) 1 Pulmonary embolism STND (n=53) 3 Deep vein thromboses 3 Myocardial farctions	6 weeks
Szendroi et al. 2006	MINI MEDM STND	8.8 ± 1.0cm 12.6 ± 1.2cm 16.1 ± 1.9cm	84 ± 16* 93 ± 18* 102 ± 12*	244 ± 100mL 265 ± 114mL 304 ± 136mL	NR NR NR	MINI (n=38) 2 Femoral nerve palsy (transient) 4 Haematoma w/ prolonged drainage 2 Deep vein thromboses MEDM (n=43) 3 Femoral nerve palsy (transient) 4 Haematoma w/ prolonged drainage 3 Deep vein thromboses STND (n=21) 2 Deep vein thromboses	3 months
Khan et al. 2006	MNI STND	8.4 ± 3.1cm 21.5 ± 3.5cm	64.1 ± 15.7min 64.3 ± 11.6min	468 ± 145mL* 838 ± 601mL*	5 days (median)* 8 days (median)*	MINI (n=100) 6 Deep and superficial infection 5 Cardiac related problems 1 Revisions STND (n=100) 5 Deep and superficial infection 4 Cardiac related problems 2 Revisions 3 Deep vein thromboses 1 Pulmonary embolism 4 Dislocations	29 months (24-37) 41 months (25-44)

Data are mean ± SD, unless otherwise indicated. MINI: mini-incision, MEDM: medium incision, STND: Standard incision. * Statistically significant comparison ($p < 0.05$). NR: Not Reported

Description of Observational Studies

Wenz et al (2002) were among the first to report on outcomes following mini-incision primary THA. These authors compared the perioperative outcomes of THA performed with mini-incision technique (n=124) with standard-incision THA (n=65), all performed between 1996 and 2001. One surgeon performed all of the mini-incision procedures (mean cut size of 7.8cm), while the standard arthroplasties (incision lengths of ≥ 25cm) were done by multiple surgeons. Patients were matched for age, sex and comorbidities, but the mini group had significantly lower BMI. Intraoperative assessments between the groups revealed that the mini-incision group averaged shorter operative times (124 min vs. 164 min) and had less estimated blood loss. In addition, no difference was found in the number of intraoperative and postoperative complication rates, and length of hospital stay. More patients in the mini-incision group were discharged to home rather than nursing care compared to the standard incision group, which suggests that mini group patients recovered more rapidly and achieved higher functional levels at discharge. The authors concluded by stating that the mini-incision approach "facilitates recovery after THA, decreases blood transfusion requirements without an increase in complication rates or operative time, and can permit earlier and more vigorous postoperative physical therapy, which may shorten hospital stays and reduce costs."

The limitations of this study include the mismatch of sample sizes, use of multiple surgeons, bias for lower BMI patients in the mini-incision group, and the lack of follow-up data.

DiGioia et al (2003) compared minimal-incision THA performed with a computer-guided navigation system with standard THA. Thirty-three patients in the mini-incision group were matched by diagnosis, gender, age, BMI and preoperative Harris hip score to 33 patients who received THA via a standard approach. The same surgeon performed all surgeries, and the navigation system was used in every operation. No difference was observed between the groups in terms of length of hospital stay. The mini-incision group had significantly higher Harris hip scores at 3- and 6-months after surgery, but this difference was not significant at the 12-month follow-up. A short-term advantage in recovery of the mini-incision group was also observed as this group was significantly better in terms of limp, distance walked, and stair climbing. At one year, however, there were no significant differences between the groups.

The limitations of this study include the small sample sizes involved, the use of multiple prosthesis types and fixation techniques, inadequate description of perioperative complications, and a short follow-up period.

Higuchi et al (2003) conducted a retrospective study that assessed intra-operative differences and complications in three groups of THA patients, who were divided into groups according to incision length. The mini-incision group (n=115) consisted of incision lengths less than 10cm, the short-incision (n=68) had lengths between 10-15cm, and the standard-incision group (n=21) had lengths greater than 15cm. All surgeries were performed by one surgeon, and device components from different manufacturers were used over the course of the study period. Preoperatively, all groups where comparable in average age. The average BMI was similar between the mini-incision and standard-incision groups, but the medium-incision group had a higher average BMI than the other groups. The authors noted a significant trend: the shorter the length of the incision, the shorter the operative duration and the smaller the intraoperative blood loss. Although there was a trend towards more complications with smaller incision size, this relationship was not statistically significant. It should be noted that the follow-up period of this study was not stated.

This study suffers from several limitations such as the use of multiple device types, unstated and likely short follow-up period, uneven sample sizes, and the preoperative variation in mean BMI among the groups.

In another case controlled study, de Beer et al (2004) compared the radiographic and clinical outcomes of a lateral approach mini-incision group (n=30) to a standard lateral approach THA group (n=30). Two surgeons performed the operations, and patients were matched in terms of gender, age, BMI, and the preoperative diagnosis was osteoarthritis. This study found no significant differences with regard to operative time, opioid consumption, postoperative blood loss, complications, length of hospital stay, flexion, Harris hip and Oxford scores at 6 weeks after surgery. These authors concluded that the length of the skin incision is clinically and functionally irrelevant.

Limitations of this study include the small sample sizes, multiple surgeons, very short follow-up period, and the use of multiple femoral component fixation techniques.

Wright et al (2004) conducted a case controlled study that compared the safety and 5-year clinical outcomes of THA performed through a mini-incision posterolateral approach (n=42) with a standard posterolateral approach (n=42). One surgeon performed all operations and identical implants and hybrid fixation was used in both groups. Although the standard THA group consisted of 42 consecutive patients, the mini-incision group was non-consecutive. Preoperatively, both groups were similar in age and Harris hip scores, but the mini-incision group had a significantly lower mean BMI. There was no difference between the groups in terms of average intraoperative blood loss (151mL for the mini group vs. 171 mL for the standard group) and length of hospital stay (6 days for both). The mean follow-up period was over 5 years for both groups, and a few patients in each group were lost to follow-up. In the mini-incision group, 2 patients died and 3 were lost to follow-up, while in the standard group 2 patients died and 1 was lost to follow-up. All deaths were secondary to events unrelated to the THA. At follow-up, no incidence of infection, nerve palsy, component malposition, or aseptic loosening was found in either group. No dislocations occurred among the mini-incision patients, but 1 dislocation occurred in the standard incision group. The Harris hip score of the abridged incision group was significantly higher (86.9 vs. 84.2), but these authors suggest that the magnitude of this difference is very small and clinically insignificant. Based on these 5-year results, the authors conclude that although THA can be performed safely and effectively through a minimal incision, there are no dramatic clinical benefits to a small incision THA other than cosmetic appeal.

Advantages of this study include its long-term follow-up and the use of a single surgeon. On the other hand, this study was limited by small sizes and the selection of slimmer patients in the mini-incision group.

Chung et al. (2004) conducted a prospective cohort study which compared the clinical outcomes of 60 patients who received minimal-incision THA with 60 patients who received standard THR. All patients had a primary diagnosis of osteoarthritis and one surgeon performed all of the surgeries. A porous-coated cup and uncemented stem were used in all patients. In the minimal-incision group, the surgical approach was posterolateral, while a posterior surgical approach was used in the standard THR group. The same post-surgical clinical pathway was used for both groups, and the analgesic protocol featured patient-controlled analgesia and timed oral analgesics. Hospital discharge was based on the patient's ability to ambulate safely and independently. The mean follow-up time was 14 months (range, 9-26 months), and no patients were lost to follow-up. Statistically significant differences were found between the groups on the amount of intraoperative blood loss, length of hospital stay, and use of walking aids, all in favour of the minimal-incision group. However, no differences were observed in analgesic use and Harris hip scores. The average Harris hip score at follow-up for the mini-incision group was 95.5, compared to 93.5 for the standard approach group. Although not significant, there was a trend towards reduced operating time with the mini-incision procedure compared to the control group. Furthermore, a comparable number of DVTs occurred in both groups, and no dislocations or obvious implant insertion errors were reported.

Particular advantages of this study include the fact that one surgeon performed all surgeries, and that all patients received the same prosthesis. On the other hand, limitations of this study include the short follow-up period, small sample sizes and limited outcome measures.

Woolson et al. (2004) conducted a retrospective cohort study based on their first experience with the mini-incision technique. In this study, the perioperative outcomes of 50 mini-incision THA patients were compared with a control group of 105 patients who received a traditional THA. A posterior approach was used in all surgeries, and three surgeons performed all of the operations. Preoperatively, the mini-incision group was significantly different on several factors. These patients were significantly more likely to be male, taller, have lower BMI and have less comorbidity, as indicated by a lower average ASA score. Furthermore, the number of obese patients in the standard-incision group was nearly six times that of the mini-incision group. No significant difference in operative time, estimated intraoperative blood loss, and complication rates was found between the groups. The major postoperative complications in the standard-incision group were a partial peroneal nerve palsy that resolved after two weeks, and a dislocation due to an in-hospital fall. In the mini-incision group, the major complications comprised of two femoral fractures, one complete sciatic nerve palsy, and a long-term wound infection. The authors stated that the complications of the mini-incision group were more serious, possibly due to the greater pressure on the skin and soft tissues from stronger retraction and more abrasion of the skin edges from reamers and rasps used during the procedure. Radiographic analysis found significantly more incidence of component malpositioning with the mini-incision procedure.

The limitations of this study include the inexperience of the surgeons with the mini-incision technique, the variance in incision size among the surgeons, the variance in component fixation techniques, the small sample sizes, and the short follow-up period.

A retrospective study by Nakamura et al (2004) reviewed the clinical results of mini-incision THA (n=50) compared to standard approach THA (n=42). Patients were matched for age, BMI and the primary reason for surgery was osteoarthritis. The mini group had significantly less operative time and intraoperative blood loss. The implants used over the study period came from several different manufacturers, and one surgeon performed all the operations. The postoperative recovery instructions were different for both groups; the mini-incision patients were instructed to bear partial weight on their new hips for a shorter period of time (1-3 weeks) than the standard incision group (4-6 weeks). No dislocations or pulmonary embolisms were observed postoperatively. However, one patient suffered a proximal femoral neck fracture in the mini-incision group, and another in the standard group had an infection that was controlled by surgical debridement without removal of the prosthesis. At 6 months after surgery, Postel Merle d'Aubigne (PMA) scores on pain, mobility and gait were not significantly different between the groups.

The findings of this study are limited by its small sample sizes, use of prostheses from multiple manufacturers, short-term and limited clinical outcomes, and different postoperative recovery schedules which could bias short-term outcome comparisons.

Howell et al. (2004) compared the perioperative outcomes of THA performed by a minimal anterolateral approach (n=50) with a standard anterolateral approach (n=57). This prospective case controlled study featured patients in both groups that were comparable in age, comorbidity scores and the major reason for hip replacement for both groups was osteoarthritis. However, slimmer patients were selected into the mini-incision group as evident by that group's lower mean BMIs. The mini-incision group had a significantly longer operation time (97 min vs. 84 min) and they had an overall quicker discharge from hospital than their counterparts (4 days vs. 5 days). Postoperative complications include two intra-operative fractures in the minimally-invasive group.

The findings of this observational study are limited by several factors. These include the use of multiple surgeons, limited samples sizes, selection bias of slimmer patients to the minimally-invasive group, no follow-up period beyond hospital release, and it is not clear if both groups followed the same postoperative rehabilitation program.

O'Brien et al. (2005) conducted a retrospective case controlled study to assess the safety of mini-incision THA compared to standard-incision THA. The objective of this study was to evaluate intraoperative and short-term postoperative complications associated with the mini-incision procedure. One surgeon performed all of the surgeries, although it is not stated whether all patients received the same prosthesis and fixation technique. In a consecutive series of 87 primary THAs, 34 were performed with a mini-incision direct lateral approach, and the other group of 53 with a standard-incision lateral THA. Heading into surgery, both groups were statistically similar in age, co-morbidities and the primary diagnosis for both groups was osteoarthritis, although the mini-incision group had significantly lower BMI. Operative time and LOS was significantly lower in the mini-group, and a higher percentage of them (94% vs. 77%) were discharged to home compared to the control group. An estimate of intraoperative or total blood loss was not reported, although there was no difference in the number of transfusions required between the groups. At 6 weeks following surgery, the rate of overall complications was similar between the groups. There were no neurological injuries, wound complications, infections or dislocation in either group at the follow-up period.

Advantages of this study include the use of a single surgeon for all procedures. The limitations include small sample sizes, very short follow-up period, and the bias for thinner patients in the mini-incision group.

In a format similar to Higuchi et al, Szendroi et al. (2006) divided 102 consecutive primary THA patients into three groups based on incision size and compared their clinical outcomes. The average incision sizes were 8.8 cm for the mini group (n=38), 12.6 cm for the medium size (n=43), and 16.1 cm for the standard approach group (n=21). It should be noted that the average standard approach incision length of this study (mean 16.1cm) is shorter than the typical standard THA incision size of 20-25 cm. The average age among the groups was similar, but the mini-incision group had significantly lower BMI than the other two groups. One surgeon performed all of the operations with a direct lateral approach, and the ratio of cemented-to-cementless prosthesis fixation was constant among all three groups. The mini-incision patients tended to be thinner (i.e., lower BMI) and, although not statistically significant, there was a trend towards less preoperative pain scores in the mini-incision group compared to the others. Similar to the finding of Higuchi et al, the authors noted a significant inverse correlation between incision length and surgical time. Furthermore, there was no difference in intraoperative blood loss among the groups. These authors also noted that, irrespective of incision length, a significant difference in total blood loss was found with respect to the type of the prosthesis (cemented vs. cementless: 642 and 868 mL respectively, p = 0.01). Radiographic assessment at follow-up found more hips with slight malpositioning of the cup in the mini-incision group. Although this did not lead to postoperative dislocations, the authors note that this could lead to impingement between the components and it could have influence implant wear and thus the long-term outcomes of the prosthesis. In summary, the authors concluded that no difference was found with regard to intraoperative and total blood loss, complication rates, and postoperative recovery. The mini-incision patients experienced less pain in the early postoperative period and were highly satisfied with the cosmetic outcome of the incision.

Overall, this study has a few limitations. The average length of hospital stay was not reported for any group, nor is it clear that the same postoperative treatments were given to all groups. Sample sizes were small, the follow-up period was short, and the mini-incision group had a lower average BMI. The observation that the prosthesis fixation type affects total blood loss in small incision THA is noteworthy.

Khan et al. (2006) compared the perioperative and 2-year complication rates and clinical outcomes in a less-invasive posterior approach THA (n=100) with a standard posterior approach THA (n=100). Preoperatively, patients in both groups were match for age, co-morbidity score, BMI, SF-36 physical component score (PCS), mean WOMAC score, and the primary diagnosis was osteoarthritis for both groups. All operations were performed by the same surgeon, and the same anaesthesia and analgesia protocols were followed by the groups. The average of the latest follow-up periods, 29 months for the less-invasive group and 41 months for the controls, differed between the groups, and four patients were lost to follow-up in both groups. This study found no difference between in the groups in operation time, although the less-invasive group had significantly less intraoperative blood loss. Chi-squared analysis indicated that the less-invasive group had significantly less complications and had shorter inpatient stay (median of 5 days vs. 8 days) compared to the standard group. Although the groups each had significant postoperative improvements on the SF-36 PCS and WOMAC scores, the differences between the groups was not significant at the 3-, 12- and 24-month follow-ups. However, a significant difference was noted when the relative improvement in the WOMAC score was compared between the groups at 3- and 12-months, but not at 24-months. Radiographic analysis at follow-up found nearly the same number of outliers with regard to component malpositioning (7 in the less-invasive group; 8 in the standard group), and no evidence of acetabular or femoral component loosening were observed in either group.

This study has acceptable sample sizes and the patients were matched on factors such as BMI, SF-36 and WOMAC scores. Patient questionnaires and radiographic analyses were performed at follow-up and the drop-out rate was described and is acceptable. The main limiting factor of this study is that it was not a randomized trial.

Discussion

Despite the fact that minimal-incision THA has been gaining popularity among surgeons, patients and the lay press, this evidence review found a limited number of comparative studies that assessed the clinical outcomes of this investigational procedure. Only two randomized, prospective clinical trials (both of high quality) were found, along with 12 lower quality comparative observational studies. The patients enrolled in these studies had a variety of indications for THA, including congenital dysplasia and osteonecrosis, although primary osteoarthritis was the most common indication. The follow-up periods of these studies ranged from the immediate post-operative period to 5 years. The lack of randomization and blinding associated with the comparative observational studies predisposes their findings to potential biases and skepticism. General limitations of these studies include variations in surgical approach techniques, prosthesis types, fixation techniques, patient BMI biases, and overall short follow-up periods with limited outcome measures.

Proponents of mini-incision THA claim that advantages such as reduced soft tissue damage, reduced blood loss, less pain, decreased surgical time, hastened recovery, shorter hospitalization, lower risk of complications, and cosmetic appeal, favour its use over standard-incision approaches to total hip replacement. [5,10,17,28] A summary of the evidence with regard to these advantages is discussed below.

Comparison of perioperative outcomes

Theoretically, a less invasive procedure which minimizes soft tissue dissection should translate into less blood loss, quicker recovery and earlier hospital discharge. Data on the comparison of operating times, estimated intraoperative blood loss and length of hospital stay reported in the included RCTs (table 2) and observational studies (table 5) between minimal-incision and standard THA is presented in table 6. This table indicates findings of significant advantage for the minimal-incision procedure over to the standard approach.

Table 6. Proposed advantages of minimal incision less-invasive THA over standard THA

Study	Study Type	Shorter Operating Time?	Less Intraoperative Blood Loss?	Reduced Hospital Stay?
Ogonda et al. 2005	RCT	✗	✓	✗
Chimento et al. 2005	RCT	✗	✓	✗
Wenz et a. 2002	Case control	✓	✓	✗
DiGioia et al. 2003	Case control	✗	NR	✗
Higuchi et al. 2003	Case control	✓	✓	NR
de Beer et al. 2004	Case control	✗	✓	✗
Wright et al. 2004	Case control	✓	✗	✗
Chung et al. 2004	Prospective Cohort	✗	✓	✓
Woolson et al. 2004	Retrospective Cohort	✗	✗	✗
Nakamura et al. 2004	Case control	✓	✓	NR
Howell et al. 2004	Case control	✓	✓	✓
O'Brien et al. 2005	Case control	✓	NR	✓
Szendroi et al. 2006	Prospective Cohort	✓	✗	NR
Khan et al. 2006	Case control	✗	✓	✓

✓ denotes statistically significant advantage reported in study. ✗ denotes no statistical difference on comparison. NR: Not reported

Operating time

Both RCTs found no statistical difference in operating time between minimal and standard exposure THA. Among the comparative observational studies 7 out of 12 reported quicker surgical times in favour of the limited exposure group. Overall, this suggests that limited exposure THA is not performed quicker or slower than standard incision total hip replacement surgery. Furthermore, the specific surgical orientation used (posterior, anterolateral, anterior, lateral, posterolateral), use of computer-assisted navigation system, and surgeon experience likely influence the operating time in minimal-incision THA procedures

Intraoperative blood loss

Minimizing the amount of soft tissue dissection should reduce blood loss. Both RCTs confirmed that (estimated) intraoperative blood loss is significantly lower in limited incision THA compared to the standard approach. Among the observation studies, 7 out of 10 found significantly less intraoperative blood loss in the mini-group. It should be noted that no difference in transfusion requirements existed between the groups in both RCTs, and Ogonda et al. found no difference in hematocrit levels between the groups at 8 hours postoperatively and at discharge. Several of the observational reports found no significant difference in the number of units of blood transfused between the groups. [19,10,11,13,21-23] This suggests that the difference in blood loss may not be clinically significant. [13]

Wright et al.[10] have noted that blood loss for both groups in their study was low due to the use of hypotensive epidural anesthesia in both groups. These authors point out that the discrepancy in blood loss between the groups may have been greater without hypotensive anaesthesia. The method of anaesthesia used and the specific surgical approach of the mini-incision technique, which could affect the amount of soft tissue disruption, may determine the clinical advantage of these techniques with respect to perioperative blood loss.

Based on the available evidence, it is likely that intraoperative blood loss is less with minimal incision, less-invasive THA.

Discharge from hospital

A few studies [13,21,22] reported earlier discharge times following less-invasive THA compared to standard THA. The authors of those studies reason that this is due to the fact that minimal surgical dissection and smaller incision translate to less pain, better mobility, and therefore earlier discharge. [13] However, this advantage was not observed in the RCTs and in the majority of observational studies. Therefore, based on the included studies, there is no evidence that patients who receive THA through a minimal-incision are discharged sooner from hospital than standard-incision patients.

Postoperative pain

O'Brien et al. have noted that postoperative pain following minimal incision THA is underreported in the scientific literature. Their assessment is in agreement with the findings of this evidence review as only a few studies assessed post-surgery pain following minimal incision THA. Ogonda et al. assessed pain levels with a visual analogue scale in 4-hour blocks up to 36 hours after THA for the mini- and standard-incision groups. These authors found no difference in pain levels at any time within this period, and patient-controlled analgesia use did not differ between the groups. In the other RCT, Chimento et al. found no difference between the groups in patient-controlled epidural anesthesia and oral narcotics consumption following surgery. Only three observational studies in this review assessed postoperative pain [1,19,23] and none reported a difference in pain levels between the groups.

Based on the evidence presented here, there is likely no difference in postoperative pain levels prior to hospital discharge between patients who receive less-invasive and standard THA. It should be noted that the surgical approach used and the amount of tissue dissection performed could affect this assessment. The lack of reporting on this measure is also noteworthy.

Postoperative improvements in function

There is conflicting evidence from the included studies regarding the potential for quicker recovery following THA with minimal-incision techniques compared to traditional THA. In their RCT, Chimento et al. found that fewer mini-incision patients limped at 6 weeks postoperatively compared to the standard-incision group, although no difference was found between the groups in the number of days required to independently transfer, ambulate with a walker or cane, and negotiate stairs. Ogonda et al. found no differences between the groups at 6 weeks postoperatively on the Harris hip score, Oxford hip score, WOMAC, and SF-12 physical component scores. Results were also inconsistent among the observational studies. Wenz et al. found earlier ambulation, less transfer assistance, and better functional recovery with early physiotherapy for the mini-incision group. DiGioia et al. found significant advantage in limp, walking distance, and climbing stairs for the mini-incision patients at 6 months, but no difference at 12 months. Khan et al. showed a significant difference in the percentage of improvement on the WOMAC in favour of the less-invasive group at 12 months, but this difference was not observed at 24 months. No postoperative differences were observed on Harris hip scores at 6 weeks (de Beer et al.) and at 14 months (Chung et al.), and on the PMA at 6 weeks (Nakamura et al).

Therefore, based on the evidence of this review, it is not clear if single mini-incision THA provides quicker recovery of function following surgery compared to standard THA. Factors such as the surgical approach used, patient factors, surgeon experience, and the outcome measures used may affect this assessment.

Complication rates

Higher complication rates could be expected with surgical techniques that impair the visual field during surgery. [29] Specifically, poor visualization may result in increased soft tissue damage, inaccurate reaming, or suboptimal component placement. This review identified one report [11] wherein the mini-incision group experienced a higher percentage of acetabular component malposition, and poor fit and fill of cementless femoral components, although it should be noted that these patients comprised the initial experience of the surgeons with this technique. Instability or misalignment of the prosethesis could result in a future revision of the implant. Unfortunately, long-term outcomes are not available. Based on the current evidence, the incidence of complications, such as nerve injury, dislocation, or intraoperative fracture, is no greater with minimal-exposure surgery than the standard-exposure operation.

Other factors in less-invasive THA

Some [11,16] have questioned whether THA performed through a limited exposure with reduced tissue dissection is significantly more tissue-sparing than standard-incision total hip replacement. An unresolved question is whether a small skin incision procedure that requires high retractor forces on the soft tissues to expose the hip joint but has less muscle dissection involved, is less traumatic to tissue than a larger incision with wider muscle dissection but with lower retraction forces. [29] One of the included observational studies in this review found poor wound healing after mini-incision procedures. [11] Chimento and associates found no significant differences in IL-6 levels, which correlate with surgical tissue trauma, between patients who had a minimal-incision or standard incision. A similar observation was made by Ogonda et al. who noted similar mean serum levels of C-reactive protein, which also correlates with tissue trauma, at 48 hours postoperatively for both the mini-incision and standard incision group.

A possible explanation for this may be due to the specific surgical approach used in those studies. Ciminiello et al. [16] proposed dividing minimally-invasive THA into two groups based on the surgical approach and intent of the surgeon. Specifically, one group pertains to a group of alternative surgical approaches with specialized instruments intended to gain access to the hip through less soft tissue dissection. The other group for THA performed through a smaller incision but where the same or similar conventional approach is used. Therefore, among the group of limited exposure techniques used (posterior, anterolateral, anterior, lateral) there may exist differences in the extent of soft-tissue disruption during THA.

Duncan et al. [3] classified the various approaches based on the nature of the deep dissection performed (table 7). Depending on the approach, during deep dissection certain muscles and tendons may have to be cut. The intentional dividing of muscles and tendons is termed transmuscular (TM), and if not, it is termed intermuscular (IM).

Table 7. Classification of single-incision approach THA

Classification	Approach	Method of dissection	Previous Designation
A-IM	Anterior	Intermuscular	Modified Smith-Peterson, Light and Keggi/Matta
AL-IM	Anterolateral	Intermuscular	Modified Watson-Jones/Roettinger
L-TM	Lateral	Transmuscular	Modified Bauer/Hardinge/Dall
P-TM	Posterior	Transmuscular	Modified Moore and others

Adapted from Duncan et al. 2006

The anterior and anterolateral approaches are believed to offer the maximum respect for periarticular structures. [30] The posterior approach requires sectioning the short external rotators. In the lateral approach, the anterior third of the gluteus medius tendon must be elevated from the greater trochantar. [30]

Both RCTs in the review used the posterior mini-approach and therefore may not have been as tissue preserving as the anterior or anterolateral approaches. Some studies suggest that the anterolateral approach may offer lower dislocation rates [31,32,33] and excellent acetabular exposure, but temporarily increase postoperative limping. [34,31] In this review, only two studies, Higuchi et al. and Howell et al., compared mini-incision THA via an anterolateral approach with standard-incision THA using the same anterolateral approach. The 3 (2.6%) dislocations incurred by the mini-incision group are among the highest rate reported among the mini-incision groups of the included studies. Howell et al. reported no dislocations in the mini group. Persistent limping among these groups was not reported in either study.

Costs of minimal-incision THA

The cost of specialized surgical instruments for minimal-incision THA has not been reported in the literature. Compared to conventional THA, costs could be higher with mini-incision procedures with the use of navigation systems, and from potentially longer operating times and higher long-term complications.

Regulatory Status

Surgical procedures, such as minimal-incision THA, do not require licensing by Health Canada.

Conclusion

The level of evidence on the clinical effectiveness and safety of minimal-incision THA compared to the standard incision surgery is currently limited and generally weak. Two high-quality RCTs were identified, along with 12 comparative observational studies. Although numerous case series reports were identified, they did not meet the inclusion criteria of this review.

There is presently no clear evidence to suggest that single minimal-incision THA has any significant clinical advantages to the patient over standard incision THA, other than a smaller scar. Minimal-incision THA may provide quicker postoperative recovery and shorter hospital stays, which could represent significant health care cost savings. However, not enough randomized, prospective trials have been conducted to confirm this.

Summary and Recommendations

- There are no long-term outcomes of minimal-incision THA.
- Two randomized, prospective clinical trials show no advantage of posterior mini-incision THA over standard-incision THA.
- There are conflicting reports from lower-quality studies regarding short-term benefits of this procedure.
- The degree of intended minimization of soft tissue dissection and damage remains uncertain.
- Candidates for less-invasive THA should understand that the procedure is investigational at this time, and that standard THA is among the best surgical treatments currently available.
- Randomized, prospective clinical trials are urgently needed to ascertain the clinical effectiveness, safety and cost benefits of the numerous forms of less-invasive THA.

Limitations

A publication bias is present as only studies published in English were selected.

Potential conflict of interest

None known

Reference List

1 Chung,W.K. *et al.* (2004) Mini-incision total hip replacement--surgical technique and early results. *J. Orthop. Surg. (Hong. Kong.)* 12, 19-24

2 Moran,C.G. and Tourret,L.J. (2001) Recent Advances: Orthopaedics. *BMJ* 322, 902-905

3 Duncan,C.P. *et al.* (2006) Minimally invasive or limited incision hip replacement: clarification and classification. *Instr. Course Lect.* 55, 195-197

4 Callaghan,J.J. *et al.* (1999) The John Charnley Award. Practice surveillance: a practical method to assess outcome and to perform clinical research. *Clin. Orthop. Relat Res.*, 25-38

5 Wenz,J.F. *et al.* (2002) Mini-incision total hip arthroplasty: a comparative assessment of perioperative outcomes. *Orthopedics* 25, 1031-1043

6 Sculco,T.P. *et al.* (2004) Minimally invasive total hip arthroplasty: the Hospital for Special Surgery experience. *Orthop. Clin. North Am.* 35, 137-142

7 Kelmanovich,D. *et al.* (2003) Surgical approaches to total hip arthroplasty. *J. South. Orthop. Assoc.* 12, 90-94

8 Jerosch,J. *et al.* (2006) Antero-lateral minimal invasive (ALMI) approach for total hip arthroplasty technique and early results. *Arch. Orthop. Trauma Surg.* 126, 164-173

9 Mack,M.J. (2001) Minimally invasive and robotic surgery. *JAMA* 285, 568-572

10 Wright,J.M. *et al.* (2004) Mini-incision for total hip arthroplasty: a prospective, controlled investigation with 5-year follow-up evaluation. *J. Arthroplasty* 19, 538-545

11 Woolson,S.T. *et al.* (2004) Comparison of primary total hip replacements performed with a standard incision or a mini-incision. *J. Bone Joint Surg. Am.* 86-A, 1353-1358

12 Sculco T.P. and Woolson,S.T. (2006) "Less invasive" hip replacement makes sense., American Academy of Orthopaedic Surgeons. http://www.aaos.org, Accessed Nov 15, 2006

13 Khan,R.J. *et al.* (2006) Less invasive total hip arthroplasty: description of a new technique. *J. Arthroplasty* 21, 1038-1046

14 Akai,M. (2002) Evidence-based medicine for orthopedic practice. *J. Orthop. Sci.* 7, 731-742

15 Ogonda,L. *et al.* (2005) A minimal-incision technique in total hip arthroplasty does not improve early postoperative outcomes. A prospective, randomized, controlled trial. *J. Bone Joint Surg. Am.* 87, 701-710

16 Chimento,G.F. *et al.* (2005) Minimally invasive total hip arthroplasty: a prospective randomized study. *J. Arthroplasty* 20, 139-144

17 DiGioia,A.M., III *et al.* (2003) Mini-incision technique for total hip arthroplasty with navigation. *J. Arthroplasty* 18, 123-128

18 Higuchi,F. *et al.* (2003) Minimally invasive uncemented total hip arthroplasty through an anterolateral approach with a shorter skin incision. *J. Orthop. Sci.* 8, 812-817

19 de Beer J. *et al.* (2004) Single-incision, minimally invasive total hip arthroplasty: length doesn't matter. *J. Arthroplasty* 19, 945-950

20 Nakamura,S. *et al.* (2004) Mini-incision posterior approach for total hip arthroplasty. *Int. Orthop.* 28, 214-217

21 Howell,J.R. *et al.* (2004) Minimally invasive versus standard incision anterolateral hip replacement: a comparative study. *Orthop. Clin. North Am.* 35, 153-162

22 O'Brien,D.A. and Rorabeck,C.H. (2005) The mini-incision direct lateral approach in primary total hip arthroplasty. *Clin. Orthop. Relat Res.* 441, 99-103

23 Szendroi,M. *et al.* (2006) The impact of minimally invasive total hip arthroplasty on the standard procedure. *Int. Orthop.* 30, 167-171

24 van Tulder,M. *et al.* (2003) Updated method guidelines for systematic reviews in the cochrane collaboration back review group. *Spine* 28, 1290-1299

25 Bilgen,O. *et al.* (2001) C-reactive protein values and erythrocyte sedimentation rates after total hip and total knee arthroplasty. *J. Int. Med. Res.* 29, 7-12

26 Grande,M. *et al.* (2002) Systemic acute-phase response after laparoscopic and open cholecystectomy. *Surg. Endosc.* 16, 313-316

27 Suter,M. *et al.* (2002) Reduced acute phase response after laparoscopic total extraperitoneal bilateral hernia repair compared to open repair with the Stoppa procedure. *Surg. Endosc.* 16, 1214-1219

28 Kennon,R.E. *et al.* (2003) Total hip arthroplasty through a minimally invasive anterior surgical approach. *J. Bone Joint Surg. Am.* 85-A Suppl 4, 39-48

29 Woolson,S.T. (2006) In the absence of evidence--why bother? A literature review of minimally invasive total hip replacement surgery. *Instr. Course Lect.* 55, 189-193

30 Laffosse,J.M. *et al.* (2006) Prospective and comparative study of the anterolateral mini-invasive approach versus minimally invasive posterior approach for primary total hip replacement. Early results. *Int. Orthop.*

31 Frndak,P.A. *et al.* (1993) Translateral surgical approach to the hip. The abductor muscle "split". *Clin. Orthop. Relat Res.*, 135-141

32 McCollum,D.E. and Gray,W.J. (1990) Dislocation after total hip arthroplasty. Causes and prevention. *Clin. Orthop. Relat Res.*, 159-170

33 Mulliken,B.D. *et al.* (1998) A modified direct lateral approach in total hip arthroplasty: a comprehensive review. *J. Arthroplasty* 13, 737-747

34 Baker,A.S. and Bitounis,V.C. (1989) Abductor function after total hip replacement. An electromyographic and clinical review. *J. Bone Joint Surg. Br.* 71, 47-50

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