International Orthopaedics (SICOT) (2007) 31:273–277
DOI 10.1007/s00264-006-0191-y

REVIEW

Constrained components for the unstable hip following total hip arthroplasty: a literature review

J. T. Williams Jr · P. S. Ragland · S. Clarke

Received: 8 May 2006 / Accepted: 10 May 2006 / Published online: 23 August 2006

Abstract Patients with chronic instability or late dislocation following total hip arthroplasty often require operative management. Unfortunately, there is an increased risk of recurrent dislocation following revision in these patients. Over the past decade the use of constrained devices for patients with chronic instability has gained increased interest; however, there is a paucity of studies available in the literature regarding the use of these devices. The purpose of this study was to analyze the available literature over the past 15 years, focusing on larger, long-term studies, to obtain recommendations from the respective articles for indications and contraindications for the use of constrained devices. Our review of eight reports included 1,199 hips in 1,148 patients with a total mean follow-up of 51 months (range, 24 to 124 months). The mean rate of dislocation following revision with a constrained liner was 10% and the mean re-operation rate for reasons other than dislocation was 4%. We concluded that constrained liners are an option for patients who have failed management of instability with other implants, those with instability of unclear etiology, those with cognitive problems who are unable to follow dislocation precautions, those with deficient abductors, and elderly or low-demand individuals with well-positioned implants requiring revision.

Résumé Les patients présentant une instabilité ou des luxations tardives de prothèse totale de hanche, nécessitent un traitement particulier. Malheureusement, il existe un risque important de luxations résiduelles après révision de prothèse totale chez ces patients. Nous avons utilisé, dans les dix dernières années, un implant contraint pour ces patients présentant une instabilité chronique. Peu d'études font part dans la littérature de l'utilisation de tels implants. Le propos de ce travail a été d'analyser la littérature des dernières quinze années sur ce sujet, afin de mettre en place des recommandations. Après cette revue de la littérature, sur 8 articles, nous avons pu analyser 1199 hanches sur 1148 patients avec un suivi minimum de 51 mois (24 à 124 mois). Le taux de luxation après révision de prothèses totales de hanche avec un insert contraint a été de 10% et le taux moyen de réintervention pour une raison autre qu'une luxation a été de 4%. Nous pouvons conclure que les inserts contraints sont une possibilité thérapeutique chez ces patients présentant une instabilité, chez les patients présentant une instabilité dont l'origine n'est pas clairement définie, chez ceux présentant des troubles cognitifs, chez ceux qui sont incapables de suivre le moindre conseil, la moindre précaution, chez ceux présentant des troubles des muscles abducteurs et chez les sujets très âgés, dont la demande fonctionnelle est peu importante et qui nécessitent la révision d'un implant.

J. T. Williams Jr. (✉) · P. S. Ragland · S. Clarke
Department of Orthopaedic Surgery,
Albert Einstein Medical Center,
Willowcrest Bldg. 4th floor, 5501 Old York road,
Philadelphia, PA 19141, USA
e-mail: Williajo@einstein.edu

Introduction

Post-operative dislocation continues to be a troublesome complication following primary total hip arthroplasty, with reported rates ranging from 1% to 10%. Studies have shown that a majority of these dislocations occur in the early post-operative period for which closed reduction and bracing provide long-term resolution in up to 70% of patients. However, for patients with chronic instability or late dislocation, operative management is often required.

Unfortunately, the risk of dislocation following revision is increased in comparison to the risk following primary procedures. As a result of this high failure rate for these patients, the use of constrained acetabular components has gained interest over the past decade, with multiple short-term studies reporting success rates of greater than 80%.

The typical indications for the use of constrained components are: failed non-operative management (three or more dislocations), failed operative modalities, idiopathic instability, abductor dysfunction, and patients with central nervous system disorders. Thus, constrained devices are usually reserved for salvage procedures in which the likelihood of failure would be unacceptably high for other operative treatment. With the increased use of constrained devices there has also been an increased level of caution expressed regarding long term survival of these devices. Some surgeons believe increased mechanical stressors inherent to these designs can affect fixation durability, osteolytic processes, and ultimately component failure. The purpose of this analysis was to determine when constrained devices should and should not be used. In this study, we reviewed the available literature to analyze reported indications and for contraindications against constrained liners. Additionally, reported failures were reviewed to derive potential contributing factors and thus expand the list of reported contraindications. This review will look at reports published over the past 15 years with an emphasis on recent long-term studies.

Materials and methods

A complete Medline review of all articles published between 1990 and 2005 was performed to analyze the reported short and long-term outcome, indications, and contraindications for the use of constrained acetabular components. All studies with 20 or more subjects and minimum 24-month follow-up were included in this review. The Medline search found thirty pertinent articles with only eight fulfilling our inclusion criteria. For studies with common subject populations we included only the latest reports. Each article was then carefully reviewed by the authors to determine the reported indications for these components. Other data retrieved included length of follow-up, rate of recurrence, and reasons for failure. The articles were then analyzed for trends to see if there was divergence in the opinions of the authors regarding the appropriate indications for use of constrained acetabular components.

In the final phase of the study we reviewed the reported modes of failure in each article to see if there were specific factors that might portend poor results.

Results

Analysis of the eight reports included 1,199 hips in 1,148 patients with a total mean follow-up of 51 months (range, 24 to 124 months). The mean rate of dislocation following revision with a constrained liner was 10% and the mean re-operation rate for reasons other than dislocation was 4%. Table 1 lists the reports included in this analysis and the respective findings.

The most common reported indications for constrained devices are: recurrent dislocation, multidirectional intra-operative instability, abductor insufficiency and neuromuscular disability; however, several authors included additional indications as listed in Table 2. Additionally, there were several mechanisms of failure reported (Table 3).

Discussion

It has been estimated that surgical treatment of recurrent instability is required after approximately 1% of all total hip arthroplasties [3]. As there are several surgical options for management of recurrent instability, constrained devices have recently gained increased interest in the orthopaedic community. However, with the increased use of these devices there has been concern with the effect of increased bony stressors, accelerated wear, component failure, and decreased range of motion. In this study, we reviewed the available literature to identify the current designs available, analyze long-term outcome, identify indications and contra-indications, and review the reported modes of failure for these devices.

Although there are currently 21 constrained designs available, we found that a majority of the reports available describe the use of the Secure Fit/Trident (Osteonics, Allendale New jersey) [1–6, 10, 13, 14, 17] (Fig. 1) constrained tripolar liners or the Duraloc/S-Rom (Depuy/Johnson and Johnson, Warsaw, Indiana) [1, 2, 7, 11] constrained system (Fig. 2). The other designs commonly used are the Ring Loc and Ring Loc II (Biomet Orthopedics, Warsaw, Indiana), which are similar in design to the Duraloc system (Fig. 3). The constrained tripolar design consists of a femoral head that snaps into a polyethylene shell with a polished cobalt-chrome backing, which in turn articulates within an outer polyethylene liner. This bipolar construction is then snapped into an Osteonics acetabular shell with constraint provided by the outer polyethylene liner [4, 9, 13, 15]. In these devices the metal locking ring design employs a reinforcing titanium ring. This ring is impacted in the polyethylene liner to secure the prosthetic femoral head after rearticulation [11, 13]. The head is constrained within the liner by extra polyethylene at the rim of the liner, and by the metal locking ring [7].

Table 1 Table showing reports included for this analysis

Author	Publication	Year	Hips/pts	Follow-up (months)	Recurrence (%)	Mean time to failure (months)	Revisions for other reasons (%)
Mcarthy et al.	CORR	2005	39/38	46	0	N/A	5
Shapiro et al.	J Arthroplasty	2003	87/84	58	2.4		8.4
Della Vaile et al.	J Arthroplasty	2005	55/51	24	16%	19	
Callaghan et al.	JBJS	2004	31/30	47	0	N/A	6
Bremner et al.	J Arthroplasty	2003	101/98	124	6	44	
Shrader et al.	JBJS	2003	110/109	38	0	N/A	8
Anderson et al.	J Arthroplasty	1994	21/21	31	29	N/A	
Berend et al.	J Arthroplasty	2005	755/720	42	17.5	29	13

Until recently, most studies provided only short-term outcomes for constrained devices. In the largest study to date, Berend and co-workers reported an overall failure rate of 42% at a mean follow-up of 10.7 years with a 29% device related failure rate and an 8.3% revision rate due to aseptic loosening [2]. Similar results were reported by Yun and co-workers who reviewed the mechanism of failure in 27 patients with 29 failed constrained devices [18]. They reported four modes of failure: (1) failure of fixation, (2) liner dissociation, (3) biomaterial failure, and (4) dislocation of the femoral head from the constrained liner, with failed fixation being the most common (13 of 29 hips). While these reports may demonstrate the risk of increased stressors at the bone-implant interface, they do not correlate with the findings of our review in which the mean rate of recurrent dislocation following use of the constrained devices was 10% and the most common mechanisms of failure were pullout and component failure.

Our review showed the most common reported indication for the use of constrained liners to be recurrent dislocation with general consistency in the authors' additional indications for the use of these devices. Additionally, several authors advocate the use of cemented tripolar liners in patients with well-fixed acetabular components at the time of revision. In the study by Callaghan and co-workers, 31 constrained liners were cemented into 31 well fixed acetabular components at the time of revision [6]. At mean follow-up of 3.9 years, they reported two failures (one due to liner dissociation, one due to component failure). They recommended cementing constrained liners into inactive or low-demand patients with well-positioned, well-fixed cups. In their study, the tripolar design achieved optimal results when the acetabular component was between 35° to 50° of abduction and 0° to 15° of anteversion. They emphasized the necessity for the native shell to accommodate the smallest available constrained liner, an adequate cement mantle, and avoidance of leaving the liner proud. Similar recommendations were reported by Shrader and coworkers who reported optimal outcome when the acetabular component varied ≤10° from 45° of abduction and 10° of anteversion [17]. In a follow-up analysis of the Callaghan study, Goetz and co-workers reported only a 7% recurrent dislocation rate in 56 hips at a mean 10.2 year follow-up [8]. In their report the authors recommended cemented liners not be left proud, avoidance of insertion into grossly malpositioned shells, positioning the liner such that the elevated rim is not likely to impinge, maximal use of screw fixation in cementless designs, and bracing for all patients for a minimum of 6 weeks post-operatively.

Another common indication noted in the literature for tripolar systems was for the neurologically impaired patient.

Table 2 Indications as reported in the study used for this analysis

Recurrent instability
Multidirectional intraoperative instability (90° flexion, 20° adduction, 30° abduction, 15° rotation)
Abductor insufficiency
Neuromuscular disability
Presence of an internal fixation device
Intraoperative instability not related to component malposition
Extensive acetabular bone loss
Inability to repair the greater trochanter
Massive femoral bone loss requiring allograft or replacement
Revision following resection arthroplasty
Neuromuscular disorders (Polio residual, Guillan Barre, Hemiparesis, Senile Dementia)
Revision following periprosthetic fracture
Failed previous attempts at stabilization
Revision following hip arthrodesis
Proximal insertion deficiency
6 or more prior dislocations

Table 3 Reported mechanisms of failure

Liner cemented proud
Traumatic failure
Shell/liner dissociation
Cup failure
Capturing ring fracture
Liner pullout
Disengagement of reinforcement ring
Impingement

Fig. 1 Image of the Secure Fit/ Trident tripolar liner

This included senile dementia and confusion, ipsilateral hemiparesis, ipsilateral polio residual, cerebral palsy, and Guillain-Barré syndrome [4, 5, 9, 12]. In the study by Goetz and coworkers, they used constrained devices in primary hip arthroplasties for patients with severe neurological impairment [6]. However, no reports compared outcomes for constrained devices to other surgical treatment modalities in this subset of patients.

This study showed that Tripolar acetabular components have also been indicated in patients with extensive acetabular bone loss and additional risk factors for instability such as a history of recurrent dislocations or loss of abductor function. In the study by Mcarthy and Lee, they reported 91% success rates at 2 to 5 years follow-up in patients in whom constrained liners were used for patients with severe compromise in abductor function [12].

The most common modes of failure reported for the tripolar design were placement of the component in excessive abduction (greater than 60°), dislodgement from the acetabulum after structural allografting, impingement of the prosthetic femoral neck against the liner, and leaving the liner proud [4, 6, 8, 12]. In the Callaghan study, it was concluded that all failures were partly due to technical error including inadequate cementing, excessive component abduction, placement of the component in bulk allograft,

Fig. 2 Image of the Duraloc/S-Rom constrained system

Fig. 3 The Ring Loc device

and placing the extended lip in an area of impingement [5]. However, based on this review the most common mode of failure was mechanical failure which included failure of the locking ring, and dissociation of the cemented liner. Excessive polyethylene wear, aseptic loosening of the femoral component, and aseptic loosening of the acetabular cup with migration has also been reported [4–6, 8, 12, 15, 16].

The reported indications for the SROM-type constrained device were similar to those reported for the tripolar design including recurrent instability, intraoperative multidirectional instability, neuromuscular and neurological abnormalities, abductor muscle or proximal insertion deficiency, and multiple revision surgeries. Additionally, the reported modes of failure were consistent with mechanical failure (dissociation of the head from the stem, dissociation of the liner from the acetabular device, and impingement with or without locking ring breakage) being the most common [1, 2, 7, 11]. Some reports evaluated the effect of the preoperative abduction angle on short and long-term outcome. In the study by Anderson and coworkers, 14 patients who did not redislocate following implantation of a constrained device had a mean abduction angle of 57° (range, 47–80) at a mean follow-up of 31 months (range, 24–64) [1]. In their study the mean theta angles of the patients who dislocated following implantation of a constrained device was 72° (range 60–85°). It was their conclusion that a constrained device may be optimal for patients with higher preoperative abduction angles (>55°), but for patients with extreme angles acetabular revision should be considered.

Some authors report no reduction in the dislocation rate for the S-Rom device. Initially, Berend and coworkers suggested that porous ingrowth acetabular components might tolerate the greater stresses of the S-ROM constrained device [2]; however, Anderson and coworkers, in a later study, noted that the increased constraint associated with this device was associated with increased loosening, wear, and osteolysis [1]. It was also noted that there was a high rate of dislocation with liner exchange alone despite the use of a modified anterolateral approach. Our review showed that the S-ROM type devices have achieved satisfactory results in high-risk patients; however, their use was abandonded in two of the larger series [1, 2].

In conclusion, constrained liners are an option for patients who have failed management of instability with other implants, those with instability of unclear etiology, those with cognitive problems who are unable to follow

dislocation precautions, those with deficient abductors, and in particularly elderly or low-demand individuals with well-positioned implants.

References

1. Anderson MJ, Murray WR, Skinner HB (1994) Constrained acetabular components. J Arthroplasty 9(1):17–23
2. Berend KR, Lombardi AV, Mallory TH, Adams JB, Russell JH, Groseth KL (2005) The long-term outcome of 755 consecutive constrained acetabular components in total hip arthroplasty: examining the successes and failures. J Arthroplasty 20(7): 93–102
3. Berry DJ (2001) Unstable total hip arthroplasty: detailed overview. Instr Course Lect 50:265–274
4. Bremner BRB, Goetz DD, Callaghan JJ, Capello WN, Johnston RC (2003) Use of constrained acetabular components for hip instability: an average 10-year follow-up study. J Arthroplasty 18 (7):131–137
5. Callaghan JJ, O'Rourke MR, Goetz DD, Lewallen DG, Johnston RC, Capello WN (2004) Use of a constrained tripolar acetabular liner to treat intraoperative instability and postoperative dislocation after total hip arthroplasty: a review of our experience. Clin Orthop 429:117–123
6. Callaghan JJ, Parvizi J, Novak CC, Bremner B, Shrader W, Lewallen DG, Johnston RC, Goetz DD (2004) A constrained liner cemented into a secure cementless acetabular shell. J Bone Joint Surg Am 86-A:2206–2211
7. Della Valle CJ, Chang D, Sporer S, Berger RA, Rosenberg AG, Paprosky WG (2005) High failure rate of a constrained acetabular liner in revision total hip arthroplasty. J Arthroplasty 20(7):103–107
8. Goetz DD, Bremner BRB, Callaghan JJ, Capello WN, Johnston RC (2004) Salvage of a recurrently dislocating total hip prosthesis with use of a constrained acetabular component: a concise follow-up of a previous report. J Bone Joint Surg Am 86-A:2419–2423
9. Goetz DD, Capello WN, Callaghan JJ, Brown TD, Johnston RC (1998) Salvage of total hip instability with a constrained acetabular component. Clin Orthop 355:171–181
10. Ito H, Matsuno T (2004) Periprosthetic acetabular bone loss using a constrained acetabular component. Arch of Orthop Trauma Surg 124:137–139
11. Lombardi AV, Mallory TH, Kraus TJ, Vaughn BK (1991) Preliminary reporting on the S-ROM constraining acetabular insert: a retrospective clinical experience. Orthopedics 14:297–303
12. McCarthy JC, Lee J (2005) Constrained acetabular components in complex revision total hip arthroplasty. Clin Orthop 441:210–215
13. Mountney J, Garbuz DS, Greidanus NV, Masri BA, Duncan CP (2004) Cementing constrained acetabular liners in revision hip replacement: clinical and laboratory observations. Instr Course Lect 53:131–140
14. Padgett DE, Warashina H (2004) The unstable total hip replacement. Clin Orthop 420:72–79
15. Shapiro GS, Weiland DE, Markel DC, Padgett DE, Sculco TP, Pellicci PM (2003) The use of a constrained acetabular component for recurrent dislocation. J Arthroplasty 18(3):250–258
16. Shapiro GS, Weiland D, Sculco TP, Padgett DE, Pellicci PM (2001) The use of a constrained acetabular component for recurrent dislocation. Instr Course Lect 50:281–287
17. Shrader MW, Parvizi J, Lewallen DG (2003) The use of a constrained acetabular component to treat instability after total hip arthroplasty. J Bone Joint Surg Am 85-A:2179–2183
18. Yun AG, Padgett D, Pellicci P, Dorr LD (2005) Constrained acetabular liners: mechanisms of failure. J Arthroplasty 20 (4):536–541