Reconstructive Review
Volume 4, Number 2, June 2014

ORIGINAL ARTICLE

Management of Medial Collateral Ligament Injury During Primary Total Knee Arthroplasty: A Systematic Review

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Abstract

Medial collateral ligament injury during primary total knee arthroplasty is a recognised complication potentially resulting in valgus instability, suboptimal patient outcomes and a higher rate of revision or re-operation. Options for management include primary repair with or without augmentation, reconstruction or immediate conversion to prosthesis with greater constraint, in conjunction with various postoperative rehabilitation protocols. Inconsistent recommendations throughout the orthopaedic literature have made the approach to managing this complication problematic. The objective of this study was to review the available literature to date comparing intraoperative and postoperative management options for primary total knee arthroplasty complicated by recognised injury to the medial collateral ligament. This systematic literature review was prospectively registered with PROSPERO (#CRD42014008866) and performed in accordance with PRISMA guidelines including a PRISMA flow diagram. Five articles satisfied the inclusion criteria. Each was a retrospective, observational cohort or case series with small numbers reported, inconsistent methodology and incompletely reported outcomes. Four of the five studies managing medial collateral ligament injury during total knee arthroplasty (47/84 patients) with direct repair with or without autograft augmentation reported good outcomes with no revision or reoperation required for symptomatic instability over a follow-up period of 16 months to almost 8 years. The fifth study with a follow-up to 10 years and a high rate of conversion to unlinked semi constrained total knee arthroplasty implant (30/37 patients) reported a greater incidence of revision due to instability, in patients in whom the medial collateral ligament injury was directly repaired without added constraint. Overall balance of evidence is in favour of satisfactory outcomes without symptomatic instability following direct repair with or without augmentation of an medial collateral ligament injury recognised intraoperatively during total knee arthroplasty. An implant with greater constraint may have reduced longevity in younger, more active patients through aseptic loosening. In elderly or less mobile patients, and in situations where the medial collateral ligament repair is deemed poor quality or incomplete, an implant with greater constraint would seem prudent. In patients where direct repair with or without augmentation was used, a period of 4-6 weeks of unrestricted rehabilitation in a hinged knee brace should be followed.

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 • DOI: 10.15438/rr.v4i2.69

Introduction

Intraoperative disruption to the medial collateral ligament (MCL) during total knee arthroplasty (TKA) is an uncommon but recognised complication reported in 0.8-8% of TKAs [1-5]. Failure to achieve long term coronal plane stability in a primary TKA may significantly influence outcomes by shortening an implant's longevity through accelerated wear, negatively affecting patient satisfaction and functional scores and ultimately leading to reoperation or early revision.

Medial collateral ligament injury during TKA is generally considered to be an iatrogenic complication [3]. Morbid obesity has been considered a risk factor contributing to intraoperative avulsion of the tibial insertion of the MCL during difficult exposure [4].

No consensus has been reached on the ideal management of recognised MCL injury during primary TKA, with options considered intraoperatively such as primary repair, immediate reconstruction or changing the implant to increase constraint. Primary repair can be attempted by direct suture apposition of a midsubstance MCL laceration, anchor or screw with post fixation of an avulsed MCL insertion, or fixation of the avulsed insertion through a transosseous bridge [2]. Augmentation of a repaired MCL has also been described with semitendinosus tendon [6] or quadriceps tendon free graft in cases with a residual gap after repair, poor quality tissue or if there was suspicion of the repair stretching postoperatively [7].

Coronal plane instability has been shown in cadaveric studies to be significantly affected by release of the deep and superficial components of the MCL [8]. Conversion of a posterior cruciate sparing implant to a posterior stabilised component in this study after release of the MCL and posterior cruciate ligament (PCL), did not provide any significant restraint to valgus laxity. Unlinked varus-valgus constrained prostheses have been advocated for the treatment of intraoperative disruption of the MCL and resultant valgus laxity [9-11]. There is reluctance, particularly in young active patients to using implants with greater constraint due to increased stresses transferred to the implant-cement and implant-bone interfaces, osteolysis, accelerated polyethylene wear and risk of subsequent aseptic loosening [12].

Furthermore, there is no agreement as to the ideal postoperative management of patients following MCL repair with or without augmentation, reconstruction or conversion to implants with additional constraint. Casting, provision of hinged bracing, degrees of freedom in bracing, weightbearing status and duration of postoperative treatment of each method are varied.

The aim of this systematic literature review was to compare predetermined patient outcomes following repair or reconstruction of recognised MCL injury during primary TKA to cases where additional constraint was used as part of the management of valgus laxity over at least 12 months from time of index operation.

Methods

The review protocol for this systematic review was registered with the International Prospective Register of Systematic Reviews (PROSPERO: http://www.crd.york.ac.uk/PROSPERO/) #CRD42014008866 prior to screening articles against eligibility criteria.

This study was designed to identify in the literature, patients of any age undergoing primary total TKA who sustain a recognised intraoperative injury to the MCL. Primary repair with or without augmentation or reconstruction of the injured MCL by any means was compared to intraoperative increase in constraint, to a prosthesis with unlinked high polyethylene post on tibial insert or linked hinged prosthesis, with concurrent repair or reconstruction of the MCL. Adequate minimum follow-up was considered to be 12 months given reported postoperative outcome scores would reflect clinically significant instability, pain or loss of function.

Intraoperative injury to the MCL reflects an unplanned complication of a primary TKA. Randomised trials were not anticipated so both retrospective and prospective original peer reviewed observational studies were considered with a minimum of 5 patients. Isolated case studies, technique guides, expert recommendations and duplicate publications were excluded.

Patients with preoperative valgus knee malalignment of greater than 10 degrees undergoing primary TKA were excluded due to the chronicity of the resultant MCL laxity. Revision TKA was included as an exclusion criterion due to difficulty in approach, high likelihood of needing complex releases and additional constraint or augmentation due to bone loss at the time of implant removal.

Exclusion criteria also included lack of basic patient demographics, subjective and objective measures taken at follow-up, duration of follow-up and any unexplained loss to follow-up.

LITERATURE SEARCH STRATEGY

A search strategy was developed to locate original human non-cadaveric journal articles across a wide range of databases without limits to language. MEDLINE online database was searched with limits from 1946 to 1st Febru-

ary 2014, EMBASE database was searched from 1974 to 1st February 2014. Proquest, CINAHL, PEDro, Cochrane Central Register of Controlled Trials (CENTRAL) and Google scholar were searched without early time limit, up until 1st February, 2014. An independent trained research librarian with experience in searching electronic databases performed the original comprehensive literature search with nominated search strategy and key words (Table 2).

Conference Proceedings, Unpublished trials, Industry reports, a manual search of table of contents from relevant chapters of major current orthopaedic textbooks, a manual search of table of contents from major orthopaedic journals (JAAOS, JBJS-Am and The Bone and Joint Journal, CORR, J Arthroplasty, Acta Orthopedica, Orth Clinics Nth America) and reference lists from screened selected articles were all cross checked for additional relevant references.

Authors of studies included in the qualitative synthesis were contacted for any longer term follow-up data not reported in these studies, in particular revision rate and reoperation for any reason.

DATA EXTRACTION

Three blinded reviewers (AK, HLO, BZ) examined all retrieved titles and abstracts and selected studies for full text review. Full text articles were retrieved and two reviewers (PDT, AS) independently selected studies based on predetermined inclusion/exclusion criteria (Table 3) and recorded data such as study aims and design, sample size, patient demographics, methodology, type of prosthesis used, intervention, outcome parameters, complications, revision/reoperation rate and follow-up on a standardised proforma developed. Discrepancies were resolved by consensus, with a third reviewer (BZ) as necessary.

Individual selected studies were rigorously assessed for risk of bias. Pre-trial bias was assessed by analysing study design, methods of patient recruitment, outcome measures, blinding methods and protocols for data collection. Information bias was assessed in each study by noting standardised patient interactions, prospective or retrospective collection and analysis of data, transfer bias and rigorous accounting of patient follow-up, clarity on description of the mechanism of recognised MCL injury and method of treatment, use of validated outcome measures and performance bias. Post trial bias analysis was analysed by noting any effects of citation bias, confounding variables and an attempt was made to determine factors affecting generalisation of the results, in particular

Table 1 - Predetermined Study Eligibility Criteria

Inclusion Criteria

1. Original peer reviewed published journal articles
2. Either retrospective or prospective
3. Observational studies or better
4. Minimum 5 patients in case series/cohort
5. Primary TKA
6. Clearly documented implant type and surgical approach during TKA used
7. Intraoperative recognition of acute MCL injury - midsubstance/origin/insertion
8. Thorough description of MCL injury repair and/or reconstruction technique
9. Method of augmentation with detailed surgical technique
10. Implant used where additional constraint was selected
11. Postoperative management and duration including weight bearing status, support with cast/brace
12. At least 12 months follow-up
13. Documentation and follow-up of predetermined outcome measures

Exclusion Criteria

1. Non human studies
2. Isolated case studies
3. Technique/opinion papers and expert recommendations
4. Duplicate publications (latest one only was considered eligible)
5. Patients with preoperative >10 degrees valgus or recognised preoperative MCL incompetence
6. Incomplete reporting of late reconstruction, reoperation rate or revision TKA
7. Lack of study population demographics
8. Inadequate or insufficient follow-up
9. Incomplete reporting of predetermined outcome measures
10. Unexplained loss to follow-up

Table 2: Search Strategy used for Medline and Embase Databases

Search strategy for Medline and Embase (Ovid MEDLINE 1946 to Feb Week 1 2014, Embase 1974 to 2014 Week 4)

1. exp medial collateral ligament/
2. medial collateral ligament.tw.
3. medial ligament/
4. MCL/
5. valgus instability/
6. instability.tw.
7. or/1-6
8. avulsion.tw
9. injury.tw
10. iatrogenic.tw
11. laceration.tw
12. or/8-11
13. exp total knee arthroplasty/
14. exp total knee replacement/
15. knee arthroplasty.tw.
16. knee replacement.tw.
17. or/13-16
18. repair.tw.
19. reconstruct$.tw.
20. augment.tw.
21. constrain$.tw.
22. ((varus valgus) or (varus-valgus)).tw
23. or/18-22
24. 7 and 17
25. 12 or 23
26. animal/ not human/
27. 24 and 25
28. 26 and 27
29. remove duplicates from 28

Table 3. Predetermined outcomes

Objective Measures:

1. Standardised knee score (eg. Oxford/Knee Society Score)
2. Knee range of motion (ROM)
3. Varus-valgus stability
4. Anteroposterior stability
5. Radiographic signs of loosening/instability
6. Reoperation rate
7. Revision operation

Subjective Measures:

1. Pain score
2. Patient satisfaction score
3. Symptomatic instability

the degree of internal and external validity.

Detailed follow-up of cases of MCL injury during primary TKA was expected due to the nature of the complication and importance of tracking outcomes through standardised examinations and validated outcome scores. Given the expected low case numbers, variability in study methodology anticipated and variety of methods used to manage intraoperative MCL injury, a descriptive synthesis of selected articles was anticipated.

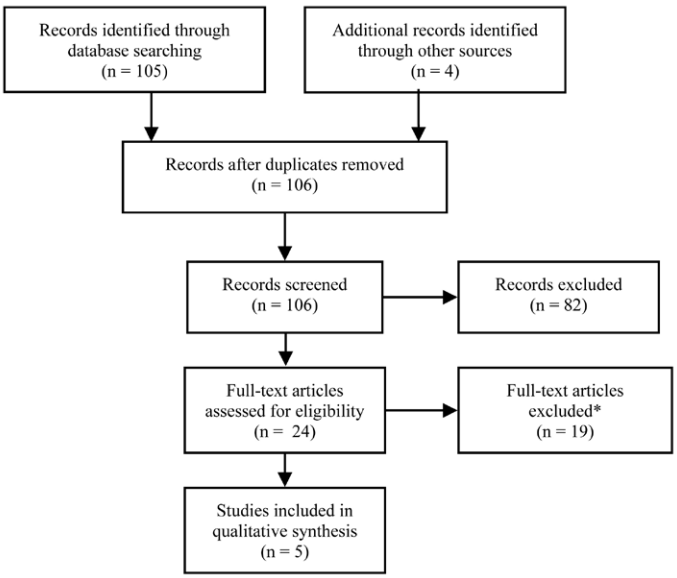
STATISTICAL ANALYSIS

A meta analysis of the studies selected for detailed analysis was not feasible due to heterogeneity, lack of randomisation, small numbers and varying methodology. A descriptive analysis was favoured given lack of directly comparable results.

Results

A comprehensive literature database search identified 105 potentially relevant studies. A manual search of relevant literature uncovered a further 4 studies, of which 3 were duplicate references. Screening of titles and abstracts of the 106 shortlisted studies excluded 82 papers and the remainder full text articles were sourced for detailed analysis.

Diagram 1: PRISMA Flow Diagram



* *Reasons for full text articles excluded:*
MCL injury recognised intraoperatively in <5 patients reported (7)
Instability/failure of MCL secondary to trauma after TKA (2)
Case series with MCL incompetence due to excessive valgus laxity (3)
Descriptive overview, not a clinical study (3)
Conference proceeding, not peer reviewed journal publication (1)
Cadaveric study (1)
Opinion paper (1)
Postoperative radiology after TKA based study (1)

A further 19 full text articles were excluded with reasons summarised in PRISMA flow diagram (Diagram 1). The remaining 5 published articles were subjected to detailed analysis with a comprehensive proforma.

The studies selected were on primary cemented TKA and had clearly documented an acute MCL injury recognised intraoperatively and the management chosen. The pooled results cover 84 patients across 5 studies.

One study was excluded from incidence calculation as it did not record the total number of TKA [13]. The remaining 4 studies totalled 69 MCL injuries affected over 5355 TKA operations in those studies which documented total number of TKA [1-3, 7]. This corresponds to an overall incidence of 1.5%.

The 5 studies selected for review were retrospective case series with well documented procedures and method of management of MCL injury (Tables 4, 5). Implant brand and model used were generally reported (Table 6). However all 5 papers had significant pre-trial bias in selection and channelling, bias during the trials and potential confounding variables not described or discussed.

Mean age across the studies was similar, ranging from 58 to 67 years. BMI was reported in 3 of the studies, with averages consistently above 30, in the range for obese. There were predominantly females in 4 of the 5 studies, gender was more equally distributed in the fifth study [1].

Each patient affected was accounted for and there was minimal loss to follow-up. Postoperative management was well documented in all studies however a complete set of objective outcome parameters was only reported in one series [3]. All 5 studies documented revision rate and Knee Society Scores.

Only one paper treated MCL laxity with increased constraint [1]. Within this study, 30/37 (81%) TKAs required immediate intraoperative revision to a semi constrained, non linked prosthesis (TCIII, DePuy). The intraoperative findings such as degree and region of MCL injury, and reasons for selecting increased constraint were not reported. Among the 84 TKAs that were treated for MCL injury, 28/84 (33.3%) were midsubstance and directly apposed and repaired with non absorbable sutures, 15/84 (17.9%) were treated non operatively with an increased thickness of polyethylene insert of 2-4mm [13]. The MCL injury was augmented with superficial, partial thickness quadriceps tendon autograft harvested in 5/84 (6.0%). Overall, 13/84 (15.5%) were avulsions from the tibial or femoral insertions and were repaired with staple, anchor or post fixation and 30/84 (35.7%) were treated with conversion to unlinked, semi-constrained (high post) prosthesis.

Four studies [2, 3, 7, 13] that used direct repair, aug-

mentation or increasing polyethylene thickness reported no further revision for symptomatic instability or aseptic loosening within 16-95 months (47/84 TKA, 56%). The patients who developed instability after repair of a MCL injury and use of a PS TKA in the fifth study were all diagnosed and revised to a unlinked semi-constrained implant within 12 months of the index TKA (4/7, 57%). Implant type was varied and ranged from CR to PS and across several designs. The higher rate of revision in one series did not appear to result from choice of implants used [1].

Knee Society Scores were generally good (70-79) to excellent (80-100) in patients where MCL was repaired with or without augmentation in 4 studies [2, 3, 7, 13]. In the other study, there were statistically significant reductions in Knee Society Pain and Function scores comparing patients who underwent TKA and sustained an MCL injury to controls, regardless of method treated, however on subgroup analysis the patients treated with increased constraint had scores similar to controls [1].

Postoperatively, most patients across the 5 studies were allowed to bear weight as tolerated without any activity restrictions. Immobilisation for 1 week, followed by restricted weight bearing with a crutch was used in all TKA routinely in one series [7], with the addition of hinged knee brace in TKA complicated by MCL injury for 4 weeks. Casting immobilisation for up to 4 weeks was used in 4

Table 4. Characteristics of included studies

Authors	Study Type	Oxford CEBM Level of Evidence	Number Affected (total case series)	Mean Age	BMI**	M : F	Prosthesis ^	Intervention	Postop protocol	Follow-up
Stephens et al [3]	Retrospective	4	9 (total 1105)	58	43.3 (29.1-55.7)	2 : 7	CR	Direct repair of midsubstance laceration	WBAT, no brace	8/9, minimum 22 months
Koo and Choi [13]	Retrospective	4	15 (*)	63.9 (56-73)	-	2 : 13	PS in 13 (Scorpio-PS (4), Genesis II (4), Nexgen LPS (5), AGC-PS (1) CR in 2	Detached tibial insertion, thicker insert used	WBAT, no brace	Minimum 2 years
Jung et al [7]	Retrospective	4	7 (2 excluded due to MCL directly repaired) (2000)	67	30.3 +/- 5.7	1 : 4	PS	2 directly repaired MCL (excluded), 5 augmented with superficial quadriceps autograft	Immobilised 1 week then restricted weight bearing with crutch, Hinged knee brace, full ROM 4 weeks&	16 months
Leopold et al [2]	Retrospective	4	16 (600)	63 (47-86)	32.5 (20-49)	4 : 10	CR (12), PS (4) where severe flexion/varus preop	Direct repair midsubstance laceration (12). Suture anchor or screw post fixation of insertion avulsion (4).	WBAT, Hinged knee brace, full ROM 6 weeks	14/16, 45 months (24-95)
Lee and Lotke [1]	Retrospective	4	37 (28 MCL transection, 9 tibial avulsion) (1650)	60	-	18 : 19	PS (7), VVC (30)	Direct suture repair (5), Tibial avulsion stapled (9), VVC (30)	WBAT, no brace (33/37), 4/37 with PS TKA were cast for 4 weeks	34/37, 54 months (36-120)

* Overall number of TKA performed over 8.5 years not reported
** Body Mass Index calculated as (Mass in kg)/(height in m)2. Units are presented as kg/m2
- Indicates not documented
^ Prosthesis type - CR (Cruciate Retaining), PS (Posterior Stabilised), VVC (Varus Valgus Constrained, non linked/semi-constrained)
& Postoperative protocol differed from controls only by use of a hinged knee brace.

Table 5. Outcomes Assessed

Authors	Postop KSS score	Postop KSS Function score	Satisfaction score	Knee ROM	Varus-Valgus instability	Antero-posterior instability	Radiographic signs loosening	Reoperation rate	Revision Rate	Symptomatic instability
Stephens et al [3]	91.5	73.3	None unsatisfied	0-120.5	Nil	Nil	Nil	1/9 for AVN patella	1/9 for sepsis	Nil
Koo and Choi [13]	91 +/- 6.78	82.50 +/- 13.57	-	0-130	1 of 15 >5deg valgus on stress xray	Nil	Nil	Nil	Nil	Nil
Jung et al [7]	87 +/- 3.7	85 +/- 3.5	-	3 - 129	Nil	-	-	Nil	Nil	Nil
Leopold et al [2]	93 (78-100)	-	-	2 - 108	Nil	Nil	2 had <1cm non progressive lucencies under medial tibial component	1 manipulation for flexion stiffness then polyethylene change for sepsis	Nil	Nil
Lee and Lotke [1]	81	74	-	-	-	-	-	-	4/7 PS knees revised for instability at average 7 months (3-12) - increased constraint 3/30 semi constrained revised (1 for sepsis, 2 for aseptic loosening)	-

- Indicates not documented

of 7 TKA that were treated with PS implant after repair/augmentation of the MCL injury [1], but this was not reported to be a factor in the higher rate revision. While 4 of 7 PS TKAs revised for instability in this series, casting amongst these patients was not reported. An unrestricted hinged range of motion brace in the postoperative period was used in 23/84 (27.4%) for between 4-6 weeks.

Discussion

Injury to the MCL during primary TKA may be caused during tibial or medial femoral condylar bone resection [1, 14]. Avulsion of the tibial or femoral insertions of the MCL may occur during high flexion in exposing the knee joint, inappropriately placed medial joint line retractors or by overly vigorous varus-valgus stressing of implants to assess stability.

Iatrogenic injury to the MCL during TKA is an uncommon but serious complication that can result in symptomatic instability, aseptic loosening of the implant, early implant failure and subsequent revision [1]. Risk factors for MCL injury during TKA include morbid obesity [4] and severe varus deformities in patients who have undergone previous knee surgery or that have considerable medial condyle bone defects [6]. Management options to achieve coronal plane stability range from inserting a thicker polyethylene liner [13], direct repair with or without autograft quadriceps or semitendinosus tendon augmentation or conversion to an implant with greater constraint [1-3, 6-8, 15].

Table 6. Prostheses Utilised

Authors	Implants used in TKA, number of patients
Stephens et al [3]	CR - PFC Sigma (Depuy, Warsaw, Indiana), 9
Koo and Choi [13]	Scorpio PS (osteonics, Allendale, New Jersey) 4 Genesis II PS (Smith & Nephew, Memphis, Tennessee) 4 NexGen LPS (Zimmer, Warsaw, Indiana) 5 AGC PS (Biomet, Warsaw, Indiana) 1 Series 7000-CR (osteonics, Allendale, New Jersey) 1
Jung et al [7]	Posterior stabilised, implant details not recorded, 7
Leopold et al [2]	NexGen CR or Miller-Galante II CR (Zimmer, Warsaw, Indiana) 12 Nexgen LPS or Insall-Burstein-II PS (Zimmer, Warsaw, Indiana) 4 (PS used if severe varus or flexion contracture)
Lee and Lotke [1]	PS - PFC Sigma (Depuy, Warsaw, Indiana) or Scorpio PS (Stryker, Mahwah, New Jersey), 7* VVC (TCIII, Depuy), 30

* Four of 7 patients revised for instability within 12 months post index TKA

Use of a unlinked, semi constrained prosthesis with a greater degree of varus-valgus stability from a metal reinforced, high tibial post can lead to increased force transmission and shearing at the bone cement interface compared to PS or CR TKA [16]. However, survivorship of unlinked, semi constrained primary TKA with either cemented or uncemented stems has been shown to be from 80-90% up to 10 years [9-12], particularly in the elderly or patients with low physical demands [16].

Collateral ligament reconstruction alone as a subsequent operation for the treatment of the unstable TKA has been shown to be ineffective [15]. Several factors were considered including artificial forces in a TKA, typically older age of the patient, poor quality tissue to repair and underlying disease process such as inflammatory arthropathy. Recognition of MCL injury and prompt action by any means to address the MCL incompetence intraoperatively is essential.

One of 5 case series reported in this review reported revision for instability [1]. The PCL has been reported to be a secondary stabiliser to valgus stress in the native knee [17, 18]. Preservation of the PCL in a TKA using a CR implant may impart a degree of additional stability in the coronal plane postoperatively. Communication with the authors of the selected studies and unpublished data located did not show any further revisions of the current cases reported for instability.

In summary, due to the variable methodology, high degree of selection and reporting bias inherent in retrospective case series and the potential for confounding error as well as incomplete reporting and low numbers in the selected 5 studies, we were unable to reach a definitive recommendation for all patients. While semi constrained TKA implants have shown good clinical outcomes up to 10 years, there is the potential for increased rates of aseptic loosening and implant failure, particularly in younger, fitter and more active patients. A less constrained (PS/CR) implant may be acceptable if a good quality direct repair with or without augmentation is possible. When an unlinked semi constrained TKA prosthesis is not available, direct repair with or without augmentation is an acceptable alternative. In cases where the MCL repair is prone to stretching, tissue quality is poor, or in the elderly, conversion to a semi constrained unlinked implant is preferable.

Postoperative management can be commenced without activity or weight bearing restriction. In direct repair with or without augmentation, the addition of a unlocked hinged knee brace for 4-6 weeks would seem prudent.

Longer term studies with larger number of patients and more detailed consistent follow-up are required to compare direct repair with or without augmentation of the MCL to survival of unlinked semi constrained prostheses in the setting of acute MCL injury during TKA.

Funding

All financial support was provided by private funds of the reviewers. No external funding, educational grants or industry assistance was involved. No author has relevant financial relationship to disclose.

Acknowledgments

Invaluable assistance was provided by the Royal Australasian College of Surgeons librarians in performing the comprehensive literature search and retrieving journal articles.

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