Reconstructive REVIEW

A Special Edition

All papers in this issue were presented at the Asia Pacific Arthroplasty Society Conference, in Delhi, India, September 2015

OFFICIAL JOURNAL OF THE



Joint Implant Surgery and Research Foundation

Strategic Alliance with





Asia Pacific Arthroplasty Society (APAS)

ISSN 2331-2262 (print) • ISSN 2331-2270 (online)

Reconstructive REVIEW

OFFICIAL JOURNAL OF THE



Joint Implant Surgery and Research Foundation

Strategic Alliance with

Joint Implant Surgeons



of the Hip, Knee, and Shoulder

An Announcement From:

Dr Rami M Sorial FRACS FAOrthA

President, Asia Pacific Arthroplasty Society & Associate Editor-in-Chief, Pacific Rim, Reconstructive Review

&

Timothy McTighe, Dr. H.S. (hc) Executive Director, JISRF,

& Editor-in-Chief, Reconstructive Review

We are pleased to announce that JISRF's journal Reconstructive Review will become the official journal for APAS. We welcome its Members to open free access to all publications and encourage its Members to submit manuscripts for publication in one of four quarterly issues.

We also welcome interested Members to become reviewers for the Reconstructive Review.

Reconstructive Review Editor-in-Chiefs Role has been Expanded Providing Global Outreach

Dr. Keith Berand, USA

Dr. Evert Smith, UK

Dr. Rami Sorial. Pacific Rim





Please visit our websites for more information:

www.jisrf.org • www.reconstructivereview.org

Stratęgic Alliance



Joint Implant Surgery & Research Foundation

is Lleased to Continue a Strategic Alliance with the



Donaldson Arthritis Research Foundation

DARF, founded in 2005 by Dr. Thomas K. Donaldson, has a focus on outcome studies and basic science with major emphasis on implant retrievals. His ongoing collaboration with Ian Clarke, PhD provides a synergy between the laboratory and clinical surgical science. Both men are Board Members of JISRF and have a significant working relationship with its Executive Director Timothy McTighe Dr. HS (hc).

JISRF, founded in 1971, has had significant experience with continuing medical education, product development, and clinical surgical evaluation of total joint implant devices.

The long term relationships JISRF has with total joint surgeons world wide and the experience of its Co-Directors and research evaluation equipment of the DARF Retrieval Center make for a strong long-term relationship.

Together both groups will provide unprecedented analysis of your Retrievals.

www.jisrf.org • www.darfcenter.org



Ian Clarke, PhD & Thomas K. Donaldson, MD



Metal on metal retrieval

The papers in this issue were presented at the Asia Pacific Arthroplasty Society Conference, in Delhi, India September 2015

The papers in this issue of Reconstructive Review were presented at the last APAS annual scientific meeting which took place in Delhi in September 2015. Our venue was the new and elegant J.W.Marriott at Aerocity. Our local convenors Dr Ashok Rajgopal and Dr Parag Sancheti ensured that the exotic flavours of India were infused throughout our meeting in many respects. It was a wonderful gathering of enthusiastic delegates and an excellent faculty delivering exceptional instructional material. With 25 invited faculty members from 10 countries, they were joined by another 11 local faculty to deliver 106 presentations. In addition there were 30 scientific papers in the free paper sessions. With 3 panel based discussion sessions there was ample presentation of complex clinical cases that led to much discussion and debate. The official debate of the conference saw the sharp and witty Bharat Mody pitted against the debonair Mojieb Mansary arguing the merits of the all poly tibia versus a modular cementless tibial baseplate. Arthroplasty's senior statesman Chit Ranawat gave us an insight into how to ensure we all mature into great orthopaedic surgeons that can contribute significantly to our community followed by Arthroplasty's gentleman Chris Dodd instructing us on the Kinematic assessment of knee arthroplasties. We also dealt with topics addressing primary and revision joint arthroplasty, bearing surfaces, approaches, periprosthetic joint infection and deformity correction. The conference banquet saw colleagues come together in a less formal gathering where great food was enjoyed with some lubrication to allow those who believed they are gifted with fine voice take to the stage to entertain us with singing and instru-

mental displays. Dato' Dr Vasan Sinnadurai's rendition of "Soldier of Fortune" will never be forgotten.

Furhtermore the industry who were present as valuable sponsors and to whom our thanks for their support is extended include Depuy, Zimmer-Biomet, Smith&Nephew, Amplitude, Global Orthopaedic Technology, Ceramtec, Stryker and MicroPort/

SurgicalSpecilaties. Without the support of the industry these meetings would not be possible.

We are now preparing an even bigger and higher quality program for APAS 2016 in Penang and hope that many of you will find time to join us there in August. The Pearl of the Orient will be an excellent venue for our next feast of arthroplasty update and local cullinary experience. The theme of this meeting will be a Bridge to Greater Knowledge and the focus will be on the diagnosis and management of periprosthetic joint infection with high profile presenters Prof. Javad Parvizi and Prof. Thorsten Gehrke sharing their experience with an excellent international and local faculty from 12 countries. Our conference site can be found at http://www.apas.acealtairtravels.com



Rami M Sorial, FRACS FAOrthA President Asia Pacific Arthroplasty Society

Reconstructive REVIEW.Org

Our new website provides a more user friendly platform for viewing and searching all past and current articles. It's based on open source software called Open Journal Systems (OJS) created by the Public Knowledge Project.

OJS was designed for the management and online presentation of open access, peerreviewed academic journals. The software has a 'plugin' architecture allowing easy integration of key features including tools to facilitate indexing in online directories such as Google Scholar and PubMed Central.



Reconstructive Review – Promoted on Four Websites

Links to Reconstructive Review and its articles are available on these websites:

- APASonline.org Asian Pacific Arthroplasty Society
- COA.org California Orthopaedic Association
- <u>ICJR.net</u> International Congress for Joint Reconstruction
- <u>JISRF.org</u> Joint Implant Surgery & Research Foundation
- <u>ReconstructiveReview.org</u>

Abstracts Indexed On:



And Searchable In: Google and Google Scholar

Reconstructive Review

A Journal Published by the Joint Implant Surgery & Research Foundation

Editor-in-Chief

Timothy McTighe, Dr. HS (hc) Executive Director, JISRF Chagrin Falls, OH, USA tmct@jisrf.org

Associate Editor-in-Chief USA

Keith R. Berend, MD Joint Implant Surgeons New Albany, OH, USA

Associate Editor-in-Chief UK

Evert J. Smith, MD

Associate Editor-in-Chief Pacific Rim

Rami M Sorial, FRACS FAOrthA

Editor Emeritus

M.A.R. Freeman, MD, FRCS London, UK

Managing Editor David Faroo Chagrin Falls, OH, USA dfaroo@jisrf.org

Copy Editor Megan McTighe Cleveland, OH, USA

Co-Directors of Research & Development, JISRF

Declan Brazil, PhD NSW, Australia, Branch

Professor Ian Clarke, PhD Orthopaedic Research at Loma Linda University & Co-Director, DARF Implant Retrieval Center

USA Editorial Board

Daniel C. Allison, MD Keith R. Berend, MD Charles Bryant, MD Harbinder S. Chadha, MD Edward Cheal, PhD Terry Clyburn, MD Douglas Dennis, MD Thomas K. Donaldson, MD Chris Drinkwater, MD Mark Froimson, MD Ron Hillock, MD Eric Hirsch, MD Riyaz Jinnah, MD Richard "Dickey" Jones, MD

International Editorial Board

Declan Brazil, PhD Warwick Bruce, MD Hugh U. Cameron, MB, ChB, FRCS David Campbell, MD Dermot Collopy, MD Dr. John M. Harrison AM Christian Kothny, MD Michael Kaplan, MD Kristaps J. Keggi, MD John M. Keggi, MD Robert "Ted" Kennon, MD Louis Keppler, MD Stefan Kreuzer, MD James Kudrna, MD, PhD Richard Kyle, MD Jeremy Latham, MA MCh FRCS Audley Mackel, MD David Mauerhan, MD Michael B. Mayor, MD Joseph McCarthy, MD Ed McPherson, MD

- Lafayette Lage, MD Lewis Samuels, MD Jasmeet Saren, MD Suresh Siva, MD, FRCS Evert Smith, Bsc, MBBCh, FRCS Rami M Sorial, MD Robert M. Streicher, PhD
- Jon Minter, DO Russell Nevins, MD Lee Rubin, MD Frank Schmidt, MD H. Del Schutte, MD W. Norman Scott, MD David Stulberg, MD Sam Sydney, MD Robert L. Thornberry, MD Thomas Tkach, MD Bradley K. Vaughn, MD

Prof. Emer. Panayot Tanchev, MD Allen Turnbull, MD Adrian van der Rijt, MD Peter Walker, MD Duncan Whitwell, MD David Wood, MD Ian Woodgate, MD

JISRF Board Members

Charles O. Bechtol, MD (Founder 1971-1998)

Louise Bechtol, R.N. (Founding member)

Keith Berend, MD Hugh U. Cameron, MB, ChB Ian Clarke, PhD Jack Diamond, Esq. Thomas Donaldson, MD Kristaps J. Keggi, MD Dr. John M. Harrison AM Edward James McPherson, MD Richard E. Jones, MD Timothy McTighe, Dr. HS (hc) H. Del Schutte, MD

Members of the TSITM Study Group posted on www.jisrf.org.

Lifetime Achievement Honorees

1991 Charles O. Bechtol, MD 1992 Charles O. Townley, MD 1993 Irwin S. Leinbach, MD 1994 Bruce D. Shepherd, MB 1995 James E. Bateman, MD 1996 Roderick H. Turner, MD 1997 William R. Murray, MD 2003 Thomas H. Mallory, MD 2007 Ian Clarke, PhD 2010 Kristaps J. Keggie, MD 2014 John H. Harrison, PM, MD

Clinical/Surgical Research Advisors:

Warwick Bruce, MD Terry Clyburn, MD John Keggi, MD Louis Keppler, MD S. David Stulberg, MD Thomas Tkach, MD Allan Turnbull, MD Bradley K. Vaughn, MD

Regional Offices

California Division Director Edward J. McPherson, MD, FACS 1414 S. Grand Ave. Suite #123 Los Angeles, CA 90015

Co-Directors of Research

Declan Brazil, PhD, Sydney, Australia Professor Ian Clarke, PhD, Loma Linda, California

Reviewers

The goal of JISRF and Reconstructive Review is to provide peer-reviewed, open-access orthopaedic articles focusing on total joint arthroplasty. To achieve this goal we rely on those individuals who are willing to take on the responsibility, and privilege, to review articles written by their peers. The following is Reconstructive Review's current list of reviewers.

Charles Alexander	Mark Froimson	Michael Manley	W. Norman Scott
Daniel Allison	Jerry Gorski	David Mauerhan	Raj Sinha
Hani Alnakhli	Kenneth Greene	Michael Mayor	Evert Smith
Christopher Anderson	William Griffin	Joseph McCarthy	Rami Sorial
Asaad Asaad	Ronald Hillock	Lorcan McGonagle	Panayot Tanchev
Keith Berend	Kirby Hitt	Harry McKellop	Panayot Tanchev, Jr.
Declan Brazil	John Ireland	Edward McPherson	Richard Tarr
Warwick Bruce	Robert Jamieson	Timothy McTighe	Jeffery Taylor
Hugh Cameron	Riyaz Jinnah	Jon Minter	Robert Thornberry
David Campbell	Richard Jones	Russell Nevins	Patrick Treacy
Edward Cheal	Maurice Jove	Steven Nishiyama	Allen Turnbull
Michael Christie	Michael Kaplan	Philip Nobel	Anthony Unger
Ian Clarke	Stephen Kayiaros	Mary O'Connor	Adrian van der Rijt
Terry Clyburn	John Keggi	Julio Palacio	Bradley Walter
Simon Coffey	Kristaps Keggi	Christopher Peters	William Walter
Richard Cook	Robert Kennon	Derek Pupello	Bill Walter
Paul Della Torre	Louis Keppler	Lee Rubin	Andrew Wassef
Paul DiCesare	Stefan Kreuzer	Mark Sacaris	Richard Welch
Thomas Donaldson	Lafayette Lage	Lewis Samuels	Duncan Whitwell
Scott Dunitz	Jeremy Latham	Kent Samuelson	Sumesh Zingde
C. Anderson Engh	Audley Mackel	Frank Schmidt	



ReconstructiveReview.org • JISRF.org • Joint Implant Surgery & Research Foundation



The Reconstructive Review (ISSN 2331-2262 print, ISSN 2331-2270 online) will be published four times a year by the Joint Implant Surgery & Research Foundation (JISRF), 46 Chagrin Plaza #117, Chagrin Falls, Ohio 44023.

Editorial Correspondence

Please direct any requests for inclusion, editorial comments or questions to Timothy McTighe, Dr. HS (hc), Executive Director, JISRF, 46 Chagrin Plaza #117, Chagrin Falls, Ohio 44023, tmct@jisrf.org.

Correspondence

Direct any questions regarding the submission process, or requests for reprints to David Faroo, Director of Communications, JISRF, 46 Chagrin Plaza #117, Chagrin Falls, Ohio 44023, dfaroo@jisrf.org.

There is no subscription charge for receipt of this publication. This is done as a service keeping with the overall mission of JISRF.

For information on how to submit articles to the Reconstructive Review please review the following or visit <u>http://www.reconstructivereview.org</u>.

Submit Articles to the Reconstructive Review

Please visit ReconstructiveReview.org to submit an article for review and publication in the Reconstructive Review. All material to be considered for publication should be submitted via this online submission system.

Before submitting an article to Reconstructive Review, please follow the instructions below.

ARTICLE TYPES

Reconstructive Review accepts the following categories of articles:

- Original Articles
- Basic Science
- Case Reports
- Clinical/Surgical
- Commentary
- Controversial Issues (i.e. modularity, tapers, MoM)
- Healthcare Policy/Economics
- Reviews
- Letters to the Editor
- Surveys

The emphasis for these subjects is to address real life orthopaedics in a timely fashion and to encourage the participation from a broad range of professionals in the orthopaedic health care field.

We will strive to be responsible and reactive to the needs expressed to our editors and all members of JISRF. We anticipate our format will evolve as we move forward and gain more experience with this activity. Your opinion is a critical step to our motivation and overall success, please do not hesitate to communicate with us.

INSTRUCTIONS FOR SUBMITTING ARTICLES

Please read the following information carefully to ensure that the review and publication of your paper is as efficient and quick as possible. The editorial team reserves the right to return manuscripts that have not been submitted in accordance with these instructions.

File Formats

- All articles must be submitted as Word files (.doc/. docx) with lines of text numbered. PDF's are not acceptable for submission.
- Figures, images, and photographs should be high quality .JPG images (at least 150 dpi, 300 dpi if possible). All illustrations and line art should be at least 1200 dpi.

Article Preparation

Articles submitted will need to be divided into separate files including cover page and manuscript. Figures, images, and photographs should be submitted separately.

- *Cover Page* includes article title, lists all authors that have contributed to the submission and provides all authors information including their title, full name, their association with the paper, their full postal address and email. Please list all authors in the order that you want them to appear.
- *Manuscript* EXCLUDES ALL AUTHOR INFOR-MATION. The manuscript is used in creating the file for peer review – a double blind process. Your submission should follow this structure:
 - Title
 - Abstract (ALL ARTICLES MUST INCLUDE AN ABSTRACT)
 - Introduction
 - Materials and Methods
 - Results
 - Discussion
 - References (for styles please refer to the website <u>http://www.nlm.nih.gov/bsd/uniform_require-</u> <u>ments.html</u>)
- *Figures, Images and Photographs* Please do not embed figures, images, and photographs in the main manuscript. They should be uploaded as individual files.

Once you have prepared your manuscript according to the information provided above, please go to our website ReconstructiveReview.org and click on the Register link. Once you have registered you will click on the Submit New Manuscript link. Detailed instructions on how to submit your manuscript can be found at ReconstructiveReview.org.

INFORMED CONSENT

Any manuscript dealing with human subjects must include a statement that proper disclosure was given and patient consent was received.

COPYRIGHT AGREEMENT

Authors retain copyright and grant the journal right of first publication with the work. Reconstructive Review follows the <u>Creative Commons Attribution-NonCommercial CC BY-NC</u>. This license allows anyone to download works, build upon the material, and share them with others for non-commercial purposes as long as they credit the senior author, Reconstructive Review, and the Joint Implant Surgery & Research Foundation (JISRF). An example credit would be: "Courtesy of (senior author's name), Reconstructive Review, JISRF, Chagrin Falls, Ohio". While works can be downloaded and shared they cannot be used commercially.

DISCLOSURE STATEMENT

Disclosure by all authors as to any commercial interest must be made by the corresponding author and all coauthors.

Note: When the paper is submitted to Reconstructive Review, the co-authors listed will automatically receive an email which will contain questions relating to the 'Disclosure statement'.

It is the responsibility of the corresponding author to ensure compliance and full disclosure of all co-authors. From your author main menu you will be able to monitor the responses received from the co-authors that you associate with your submission.

Reconstructive Review Production Specifications

The Reconstructive Review is currently constructed using InDesign running on a Mac. The document is published on the web, available for download as a PDF at jisrf. org, and printed in limited quantities.

- Trim Size: 8.5" x 11"
- Live Area: 7.25" x 9.25"
- No Bleeds
- Ad Specification
- Full color or black and white available sizes:
- Full Page, 7.25" x 9.25"
- Half Page Horizontal, 7.25" x 4.25"
- Half Page Vertical, 3.25" x 9.25"

Any questions regarding these specifications should be directed to media@jisrf.org.

General Statement

The ideas, opinions and statements expressed in the Reconstructive Review do not necessarily reflect those of the publisher and or editor of this publication. Publication of advertisement does not indicate an endorsement of product or service by the publisher or editor of JISRF. The publisher and editor assume no responsibility for any injury or damage resulting out of any publication of material within the Reconstructive Review. The reader is advised to review and regard with balance any information published within this publication with regard to any medical claim, surgical technique, product features or indications and contraindications. It is the responsibility of the professional treating medical physician to review any and all information before undertaking any change of treatment for their patients.

CONTENTS

Reconstructive Review Volume 6, Number 2, July 2016

- 13 Combination Intravenous and Intra-Articular Tranexamic Acid Compared with Intravenous Only Administration and No Therapy in Total Knee Arthroplasty: A Case Series Study *Buntting C, Sorial R, Coffey S, Eslick G*
- 21 Our Experience with Short Stem Hip Replacement Surgery *Rastogi S, Marya S*
- 31 Quadriceps Tendon Rupture and Contralateral Patella Tendon Avulsion Post Primary Bilateral Total Knee Arthroplasty: A Case Report Sharma G, Bagaria V, Nadange S, Waghchoure C, Shah S, Tangirala R, Wadia F
- 37 Total Hip Arthroplasty in Sickle Cell Disease *Manzary M*
- 43 SuperPATH Minimally Invasive Total Hip Arthroplasty An Australian Experience *Qurashi S, Chinnappa J, Rositano P, Asha S*
- 58 Disclosure Statements

A Call for Papers

We welcome your ongoing support and encourage you to submit any new papers via our website: ReconstructiveReview.org.

Topics include:

- Original Articles
- Basic Science
- Case Reports
- Clinical/Surgical
- Commentary
- Controversial Issues (i.e. modularity, tapers, MoM)
- Healthcare Policy/ Economics
- Reviews
- Letters to the Editor
- Surveys

We are also looking to expand our base of reviewers.

If you would like to become a reviewer for Reconstructive Review please visit our website to register.

If you require any

assistance please contact David Faroo, Managing Editor at dfaroo@jisrf.org.



Reconstructive REVIEW



CASE REPORT

http://dx.doi.org/10.15438/rr.6.2.138

Combination Intravenous and Intra-Articular Tranexamic Acid Compared with Intravenous Only Administration and No Therapy in Total Knee Arthroplasty: A Case Series Study

Buntting C¹, Sorial R¹, Coffey S¹, Eslick G¹

Abstract

Introduction: Excessive perioperative bleeding requiring transfusion remains a potential complication of Total Knee Arthroplasty (TKA). There is overwhelming evidence supporting the efficacy of intravenous Tranexamic acid to reduce bleeding and the need for transfusion in TKA. There is still some question regarding the efficacy of other methods of Tranexamic acid administration. This case series study evaluated the effects of the use of intravenous Tranexamic acid administered alone, or in combination with intra-articular tranexamic acid on transfusion rate and other clinical outcomes; and compared this to a group of patients who received neither treatment.

Method: We conducted a case review of 150 patients who had undergone TKA from 2012-2015. 50 patients underwent TKA with IV Tranexamic acid (Group A). A further 50 patients underwent TKA with IV Tranexamic acid in combination with intra-articular administration of 2grams of Tranexamic acid in 20ml saline (Group B). A final 50 patients underwent TKA without the use of Tranexamic acid (non-treatment group). Outcome measures were transfusion rate, change in haemoglobin and haematocrit, medical review events, patient mortality and changes in knee flexion and extension measurements at six weeks after surgery.

Results: There were no significant differences in red blood cell transfusion rates between the non-treatment group and the two treatment groups, however an absolute reduction in transfusion rate from 8% to 0% (p=0.134) was observed. The mean change of haemoglobin level in the non-treatment group was 29 while in treatment groups A and B, this was 23 and 19 respectively (p=0.0001). No significant difference was observed between treatment group A and B.

There was a significant difference in post-operative haemoglobin level, where mean haemoglobin

1	Chris Buntting, MD, Rami Sorial, MD, Simon Coffey, MD, Guy Eslick, MD	(
	Nepean Hospital, Derby St, Penrith 2750, Australia	A
	(Direct reprint requests to Simon Coffey)	R

^{© 2016} Buntting, Sorial, Coffey, Eslick. All rights reserved. Authors retain copyright and grant the journal right of first publication with the work. Reconstructive Review follows the <u>Creative Commons Attribution-NonCommercial</u> <u>CC BY-NC</u>. This license allows anyone to download works, build upon the material, and share them with others for non-commercial purposes as long as they credit the senior author, Reconstructive Review, and the Joint Implant Surgery & Research Foundation (JISRF). An example credit would be: "Courtesy of (senior author's name), Reconstructive Review, JISRF, Chagrin Falls, Ohio".

concentrations in non-treatment, Group A and B were 110 vs 115 vs 123 respectively (P=0.0001). Pairwise comparison showed that Group B was significantly different when compared to both non treatment (p=0.0001) and treatment group A (p=0.020). There were no significant differences observed in other outcomes.

Conclusion: This study supports the existing literature and suggests that the use of IV Tranexamic acid alone or in combination with intra-articular dose in TKA may reduce the requirement for transfusion (Level IV evidence). Furthermore, this study suggests that the use of tranexamic acid as a combination of Intravenous and intra-articular administration has no effect on range of motion, or medical complications during hospital stay. Although it was not a statistically significant finding, our study suggested a trend towards a greater reduction in haemoglobin and haematocrit fall in the combination therapy group when compared to IV Tranexamic acid alone.

Keywords: arthroplasty, replacement, knee, tranexamic acid administration, intravenous injections, intra-articular treatment outcome range of motion, articular blood loss, surgical **Level of Evidence**: AAOS Therapeutic Level IV

Introduction

Total knee arthroplasty (TKA) is a commonly performed orthopaedic procedure which provides significant pain relief and improves the quality of life of patients suffering arthritic disorders of the knee. In 2013 over 51 000 primary knee replacements were undertaken in Australia, a figure testament to the efficacy and demand for this procedure [1]. Excessive perioperative bleeding remains a potential complication of TKA in which blood loss ranges from 500ml to 1.5L [2-7]. Furthermore, true blood losses may be underestimated as often hidden blood losses are not taken into account [6,7]. Regardless, a reduction in haemoglobin concentration by 20-50g/L has been observed following TKA [5-8]. This may lead to post-operative anaemia with prevalence rates estimated to be approximately 51% in patients who have undergone TKA [9].

Post-operative anaemia has been associated with morbid outcomes including increases in the length of hospital stay, poorer post-operative physical function, an increase in infection rates and increased rates of readmission [9,10]. However, there exists conflicting evidence surrounding the effects of post-operative anaemia in patients who have TKA. Some studies suggest that there is no effect on physical function, quality of life and morbidity between anaemic and non-anaemic patients who have undergone TKA [10-14]. Red blood cell transfusion is often implemented to treat anaemia and the rate of red blood cell transfusion in TKA has been reported to be as high as 10-69% [9,15]. Patients who receive a transfusion are exposed to many well documented risks. These include the risk of inoculation with blood borne pathogens, the risk of venous and arterial thromboses, and a number of immune mediated disorders [16]. Furthermore, it is unclear whether treatment of established anaemia in the post-operative period is beneficial; and strategies have been aimed at reducing the incidence of post-operative anaemia rather than its treatment.

A number of factors contribute to blood loss and the development of post-operative anaemia. These include the vascular nature of the knee joint and unavoidable trauma due to dissection, tissue release and bone cuts [5,17]. Furthermore, alterations in haemostasis also occur. Specifically, a hyperfibrinolytic state is induced through the excessive release of tissue plasminogen activator which activates plasmin resulting in the cleavage of fibrin clots, and excessive bleeding [18,19]. Additionally, alterations in iron metabolism and erythropoiesis occur in response to the inflammatory cytokines released after surgery resulting in reduced haematopoiesis [20]. Further factors such as the use of tourniquet, incision type and type drainage systems used have also been implicated in causing excessive blood loss.

A number of strategies have been developed to reduce blood loss and the requirement for red blood cell transfusion in TKA. These include deliberate hypotension, regional anaesthetic techniques, variation in incision approaches and the use or absence of drain systems. The administration of erythropoietin stimulating agents and iron supplementation has also been trialled with varying results [21-35]. One intervention which has been demonstrated to significantly reduce blood loss in TKA and the requirement for transfusion is the use of intravenous Tranexamic acid.

The antifibrinolytic Tranexamic acid is a synthetic analogue of the amino acid lysine. Its effects on blood loss have been extensively studied and its safety is well established in many medical specialties [36]. Tranexamic acid is thought to exert its effect by competitively binding and inhibiting the lysine residues of plasminogen molecules, rendering them unable to be converted to plasmin by tissue plasminogen activator (TPa). At high doses it is thought that Tranexamic acid directly inhibits the activity of plasmin, therefore further decreasing the fibrinolytic properties of plasmin. Overall an anti-fibrinolytic phase is induced which reduces overall blood loss.

Several large studies and meta-analyses have demonstrated a reduction in blood loss and requirement for transfusion with the use of intravenous tranexamic acid [3638]. In their comprehensive meta-analysis, Yang et al [34] found a significant reduction in the rate of transfusion (OR, 0.16 [95% CI, 0.10 to 0.25]; p < 0.0001). Similarly, in their meta-analysis Tan et al [38] found a reduction in transfusion rate (RR, 0.39 [95% CI, 0.25-0.61]; P < 0.0001). Neither study demonstrated an increase in venous thromboembolic events nor other complications related to intravenous Tranexamic acid administration.

Thus there is overwhelming evidence supporting the use of intravenous Tranexamic acid in total knee arthroplasty. A number of studies have also evaluated the effects tranexamic acid when administered intra-articularly and have demonstrated similar reductions in blood loss and haemoglobin fall [39-41]. However, there is a limited database examining the clinical effects when the combination of intravenous and intra-articular tranexamic acid is used in Total Knee Arthroplasty [42]. The present study aimed to evaluate whether the combination of the use of intravenous Tranexamic acid in combination with intra-articular administration reduced transfusion rates and the change in haemoglobin and haematocrit levels on the first day after surgery. This study also evaluated the effect of this combination on the frequency of medical review events, patient mortality, and changes in knee range of motion at six weeks after surgery.

Our hypothesis was that the use of intravenous Tranexamic acid with or without Intra-articular administration would reduce any transfusion requirements; that the change in haemoglobin and haematocrit fall observed would be reduced; and that there would be no significant difference in flexion and extension measurements at six weeks as compared to the non-treatment group; and finally that there would be no difference in outcomes between Intravenous Tranexamic Acid administration and combination administration.

Method

Study Design

We designed and conducted a case series study of patients who had undergone total knee arthroplasty (TKA) and had received intravenous tranexamic acid alone or in combination with an intra-articular dose of Tranexamic acid. Our study was approved by the Nepean Blue Mountains Local Health District Human Research Ethics Committee.

Patient Selection

A sample of patient's records was drawn from the practices of two surgeons (Surgeon A and Surgeon B) and data was collected and patients organized into three groups. One group studied consisted of patients who had undergone TKA in 2012 and had not received intravenous Tranexamic acid (non-treatment group). The other group studied consisted of patients who had undergone TKA in 2014 and 2015 and had received intravenous Tranexamic acid only (treatment group A). The third group of patients was composed of patients who had undergone TKA in 2015 and had received a combination of intravenous tranexamic acid and an intra-articular dose of tranexamic acid (treatment group B).

In both treatment groups of the study we required that three total doses of IV Tranexamic acid were administered to patients. The first dose occurred in the intraoperative period and two further doses in the postoperative period with the second dose administered eight hours after surgery, and the third eight hours after the second dose. The dose of Tranexamic acid varied depending on the protocol used by the anaesthetist at surgery. Some patients were administered a 10mg/kg dose while others were administered a standard 1g dose delivered as a bolus. In treatment group B, it was required that the dose of intra-articular tranexamic acid administered was 2g in 20ml saline, which was left for 5 minutes before being removed via suction. Patients in the non-treatment group were included in the study if they had not received Tranexamic acid in any form.

Patients were universally excluded from the study if they were undergoing revision TKA surgery; and if they had received an iron infusion, haematopoietic colony stimulating factor or blood product transfusion prior to surgery. Patients that suffered from chronic renal failure, chronic anaemia, haemophilia, thrombophilia, other coagulation disorders or current cancer were also excluded from the study.

Outcomes

The primary study outcomes were defined as red blood cell transfusion rate in the post-operative period, and haemoglobin and haematocrit changes. Secondary outcomes included post-operative medical review events, measures of knee flexion and extension prior to surgery and six weeks after surgery, and mortality at six weeks after surgery.

Red blood cell transfusion rate was defined as the sum of the units of red blood cells transfused per patient group divided by the sum of patients in that group. Changes in haemoglobin and haematocrit levels were measured as the difference between the pre-operative and post-operative values the day after surgery. This time frame was chosen because of the short half-life of Tranexamic acid (3 hours). Haemoglobin and haematocrit values were chosen to assess blood loss because of likely error in visual assessment and the association of haemoglobin levels with morbidity and mortality [6,7].

Medical complications were defined as local infection, sepsis, venous thromboembolic disease, myocardial infarction, stroke, or other. Where a medical complication was of the 'other' category the details of the diagnosis were recorded. Intravenous fluid requirements were defined as the total volume of fluids other than blood products which were ordered by a doctor in the post-operative period up to discharge.

Knee flexion and extension measurements prior to surgery and six weeks after surgery were extracted from clinical notes. These measurements were made by Surgeon A or B without the use of general anaesthesia. Finally, mortality data was defined as death within the post-operative period to the date of follow up at six weeks.

Patient demographic and clinical characteristics were defined as patient gender, age at surgery, comorbidities, patient weight, and indication for surgery, and side that TKA was performed. Details concerning the dose of intravenous Tranexamic acid and tourniquet application time, were found in operative notes and patient medical records.

A structured data extraction tool was created and use to collect and organise data from patients' medical records. The items of the data extraction tool elicited data concerning inclusion and exclusion criteria, primary and secondary outcomes, patient demographic information and clinical characteristics. The data collected was then entered and stored on an Excel spreadsheet. A single researcher collected and stored this data.

Statistical Analysis

All statistical analysis was performed using SPSS v.22.0 (IBM Corp., Armonk, NY, USA). Propensity score matching was employed in our study to match for patient characteristics. This method was implemented to reduce bias inherent in retrospective studies [47]. The covariates controlled for were age at surgery, gender, pre-operative haemoglobin concentration and pre-operative haematocrit. Match tolerance was set at 0.1.

The Kruskal-Wallis H Test was used to analyse for any significant difference amongst the three groups of patients, and where significance was found, a pairwise comparison of means was conducted to compare the means of the outcomes in the treatment and non-treatment group. This technique was used to compare baseline characteristics of the treatment and non-treatment groups. These statistical techniques were used as it was assumed that there was not a normal distribution of values due to the small sample size. All P-values calculated were two-tailed; and the alpha level of significance was set at 0.05. Patient demographic and

clinical characteristics were reported as mean and standard deviation or confidence interval for numeric-scaled features and percentages for discrete characteristics.

Results

A total of 282 patients were studied from the records of the authors and medical records. This consisted of 128 patients who had not received intravenous Tranexamic acid, and a further 92 patients who had received Tranexamic acid, and a further 62 patients who had received a combination of intravenous tranexamic acid and intra-articular tranexamic acid. The entire medical record for each patient was investigated and data extracted using the data extraction tool. Inclusion and exclusion criteria were then applied resulting in a total of 50 patients in treatment group A, 57 patients in treatment group B, and 81 patients in the non-treatment arm. The non-treatment group (n=81) and treatment group B were then matched with the treatment group A (n=50). This resulted in a complete match and 50 patients per group.

Baseline Characteristics

There were no significant differences in baseline characteristics between the treatment group and the non-treatment group. Baseline characteristics of both treatment groups and non-treatment groups are listed in table 1. In all arms there were a larger proportion of female patients (64%, 68% and 56%, p = 0.412) and the majority of patients suffered from osteoarthritis.

Surgical Characteristics

The surgical care of patients included in the studied differed only in the interventions that were studied (Table 2). In the non-treatment arm, the average length that the tourniquet was kept inflated was 54 minutes (20 S.D.) while in Treatment Group B this was 13 minutes (15 S.D.). The average dose of Tranexamic acid administered in three doses to treatment group A and B was 1.1g (0.2 S.D.) and 0.9g (0.1 S.D.) respectively. There was no significant difference between groups in terms of the use of drains and the proportion of patients that required patellar resurfacing.

Primary Outcomes

The primary outcomes are listed in Table 3. There were no significant differences in red blood cell transfusion rates between the non-treatment group and either of the treatment groups (4 vs 0 vs 0, p=0.134), however no patients in the treatment groups required transfusion. There was a significant difference in post-operative haemoglobin level,

	No Treatment	IV Tranexamic	Combination IV and	P-Value
Sample Size	50	50	50	
Mean Age (years)	65 (8.4 S.D.)	66 (9.1 S.D.)	68 (7.6 S.D.)	0.101
Gender: - Female - Male	32 (64%) 18 (36%)	34 (68%) 16 (32%)	28 (56%) 22 (44%)	0.412
Patient Weight (kg)	89.4 (19.3 S.D.)	92.9 (20.7 S.D.)	89.3 (7.6 S.D.)	0.667
Indication: - Osteoarthritis - Rheumatoid Arthritis - Other or Unspecified	50 (100%)	47 (94%) 2 (4%) 1 (2%)	50 (100%)	1.00
Pre-Operative Haemoglobin	139 (13.1 S.D.)	138 (10.6 S.D.)	142 (12.7 S.D.)	0.224
Pre-Operative Haematocrit	0.42 (0.03 S.D.)	0.42 (0.03 S.D.)	0.43 (0.04 S.D.)	0.037

Table 1: Demographic and Clinical Characteristics of Patients

Table 2: Surgical Characteristics of Non-Treatment and Treatment Groups

	No Treatment	IV Tranexamic Acid	Combination IV and IA Tranexamic Acid	P-Value
Mean Dose of IV TXA	0	1.1 (0.2 S.D.)	0.9 (0.1 S.D.)	0.001
Mean Tourniquet Time	54 (20 S.D.)	0	13 (15 S.D.)	0.001
Side of Operation - Left - Right	23 (46%) 27 (54%)	34 (68%) 16 (32%)	19 (38%) 31 (62%)	0.427
Average number of drains	2 (0.7 S.D.)	2 (0.8 S.D.)	2 (0.8 S.D.)	0.101

Table 3: The transfusion rate an	ıd haemoglobin anı	d haematocrit	change obse	erved after	Total Knee
Arthroplasty					

	No Treatment	IV Tranexamic Acid	Combination IV and IA Tranexamic Acid	P-Value
RBC Transfusion - Total - Mean	4 0.08 (8%)	0 0 (0%)	0 0 (0%)	0.134
Mean Post- Operative Haemoglobin (g/L)	110 (11.7 S.D.)	115 (12.4 S.D.)	123 (16.3 S.D.)	0.0001
Mean Change in Haemoglobin (g/L)	29 (7.2 S.D.)	23 (6.8 S.D.)	19 (13.9 S.D.)	0.0001
Mean Post- Operative Haematocrit	0.34 (0.03 S.D.)	0.35 (0.04 S.D.)	0.37 (0.03 S.D.)	0.0001
Mean Change in Haematocrit	0.08 (0.2 S.D.)	0.07 (0.02 S.D.)	0.06 (0.03 S.D.)	0.0001

where mean haemoglobin concentrations in non-treatment and treatment groups A and B were 110 vs 115 vs 123 respectively (P= 0.0001). Pairwise comparison showed that combination therapy was significantly different when compared to both non treatment (p=0.0001) and treatment group A (p=0.020).

The mean change of haemoglobin levels in the no treatment group was 29 while in treatment groups A and B, this was 23 and 19 respectively (p=0.0001). However, there was no significant difference observed between treatment groups. There was also a significant difference in the change in haematocrit between non-treatment group and Treatment Group A and B (0.08 vs 0.07 vs 0.06, p=0.0001), with pairwise comparisons showing a difference in Treatment Group A and No Treatment (p=0.032), and Treatment Group B and No Treatment (p=0.0001). Again no significant difference was observed between the two treatment groups.

Secondary Outcomes

The secondary outcomes are listed in table 4. No deaths occurred during the admission period and follow up period of this study. There was an absolute difference in medical review events between the non-treatment group and treatment group A and B respectively (6 vs 12 vs 10, p=0.295), however no medical review events matched the known adverse effect profile of tranexamic acid. Mean flexion and extension measurements were similar at six weeks post-operatively in all groups.

Discussion

We conducted a case series study with the primary aim of evaluating the effects of the use of the combination of intra-articular and intrave-

	No Treatment	IV Tranexamic Acid	Combination IV and IA Tranexamic Acid	P-Value
Death	0	0	0	
Medical Review Events - Sum - Mean	6 0.12 (0.33 S.D.)	12 0.24 (0.43 S.D.)	10 0.1 (0.40 S.D.)	0.295
Mean Post- Operative Range of Flexion (degrees)	108 (11.8 S.D.)	105 (15.5 S.D.)	108 (18.9 S.D.)	0.284
Mean Post- Operative Range of Extension (degrees)	3 (5.0 S.D.)	2 (4.1 S.D.)	2 (4.2 S.D.)	0.498

Table 4: Mortality, total fluid requirements, medical review and range of motion data after total knee arthroplasty.

nous tranexamic acid in TKA, and compared this to the use of intravenous Tranexamic acid alone and a non-treatment group. Outcomes measured included the transfusion rate, change in haemoglobin level and change in haematocrit level. We also evaluated whether a difference in final extension and flexion measurements was observed at six weeks; and whether there was a difference in the sum of events that required medical review.

Our study demonstrated a reduction in transfusion rate with the use of both methods of tranexamic acid administration, and a reduction in haemoglobin and haematocrit fall in patients treated with intravenous Tranexamic acid and combination treatment when compared to no treatment. A significant difference was observed between combination therapy and IV Tranexamic acid alone where final haemoglobin levels were concerned but not in the change in haemoglobin levels, which may reflect differences in pre-operative haemoglobin levels and the cumulative effect of the difference in the change in haemoglobin.

A reduction in transfusion rate from 8% in the non-treatment group to 0% in both treatment groups (p = 0.134) was observed. The mean reduction in haemoglobin level was 23 g/L in treatment group A and 19g/L in treatment group B, as compared to 29 g/L (p = <0.0001 in the non-treatment group); Pairwise analysis revealed a significant difference between Treatment Group A and no treatment (p=0.003) and Treatment Group B and no treatment (p=0.0001).

There was also a significant difference in the change in haematocrit between non-treatment group and Treatment Group A and B (0.08 vs 0.07 vs 0.06, p=0.0001), with pairwise comparisons showing a difference in Treatment Group A and No Treatment (p=0.032), and Treatment Group B and No Treatment (p=0.0001). These results are expected and are consistent with existing knowledge concerning the use of Tranexamic acid in total knee arthroplasty. Despite not being a statistically significant finding, our study suggested a trend towards a smaller haemoglobin and haematocrit loss in treatment group B (topical and IV) when compared to group A (IV alone).

There were no differences in mortality between groups. Furthermore, we found that the number of medical review events was not significantly different between the three groups and there were no events which matched the known adverse profile of Tranexamic acid in total knee arthroplasty. This was an expected result due to the design of our study, and the

exclusion and inclusion criteria employed. This study selected for patients with limited comorbidities and patients who had a contraindication to receiving Tranexamic acid were excluded. Furthermore, mortality in TKA is very rare [46]. Our study reaffirms previous multiple meta-analyses which suggest that Tranexamic acid is a safe pharmacotherapeutic.

The use of combination therapy, intravenous tranexamic acid alone or no tranexamic acid appeared to have no effect on the range of motion achieved at six weeks when intravenous Tranexamic acid was used in TKA. The absolute mean post-operative flexion in non-treatment and treatment group A and B was 108 vs 105 vs 108 degrees respectively (p = 0.284). Mean post-operative extension measurements also did not differ significantly between non-treatment and treatment group A and B (3 vs 2 vs 2, p = 0.498) The mean post-operative flexion achieved at 6 weeks in both groups supports existing literature which suggests that patients can expect an improvement in flexion of 95-110 degrees [43,44].

The significance of our findings regarding range of motion suggest that there is no evidence of stiffness being induced by the use of tranexamic acid when applied topically, intravenously or both. Similarly, higher blood loss does not seem to have resulted in stiffer knees. It is likely that other factors have a greater influence on range of motion outcomes than the application of tranexamic acid in intravenous or intra-articular forms [43,44].

There are several limitations to our study. Firstly, the study design was a case series which implies the potential for confounding variables to influence the outcome. The retrospective nature of the control group in the study is an additional limitation. Finally, surgeon performance characteristics were not measured and these may have also changed over the period of time of the study. To accommodate for these limitations, a minimum sample size was calculated to measure the primary outcome of our study. Furthermore, propensity score matching was used to reduce the impact of the retrospective nature of the control group on the study.

Conclusion

Our study has confirmed the findings of previous studies that have attempted to measure the effects of Tranexamic acid in total knee arthroplasty. We found an absolute reduction in transfusion rates between groups and a significant reduction in the fall in haemoglobin and haematocrit, without any changes in short term outcomes between our study groups when tranexamic acid was used. The use of Tranexamic acid serves as a safe method of reducing transfusion requirements in patients undergoing total knee arthroplasty regardless of whether it is used alone intravenously or in combination with an intra-articular administration; although our study does suggest a slightly less haemoglobin reduction when intra-articular administration is combined with intravenous administration. We suggest that future research be directed at studying feasible, cost effective regimes aimed at reducing transfusion requirements which may incorporate other interventions such as transfusion protocol changes in addition to the use of Tranexamic acid.

Disclosure

The authors declare that there is no conflict of interest regarding the publication of this paper. For full disclosures refer to last page of this journal.

References

- Australian Orthopaedic Association National Joint Replacement Registry (2014). Lay Summary2014 Annual Report Hip and Knee Replacement. Retrieved from: https://aoanjrr.dmac.adelaide.edu.au/documents/10180/172288/Lay%20Summary%202014%20Annual%20Report%20Hip%20and%20Knee%20Replacement.
- Callaghan J.J., O'Rourke, M.R., & Liu, S.S. (2005) Blood management: issues and options. The Journal of Arthroplasty. 20(4), Supplementary 2, 51-4.
- Keating, E.M., Meding, J.B., Faris, P.M., & Ritter, M.A. (1998). Predictors of transfusion risk in elective knee surgery. Clinical Orthopaedics and Related Research. 357, 50-59.
- Bierbaum, B.E., Calaghan, J.J., Galante, J.O., Rubash, H.E., Tooms, R.E., & Welch RB. An analysis of blood management in patients having a total hip or knee arthroplasty. Journal of Bone and Joint Surgery. 81(1), 2-10.
- Page, M.H., Shepherd, B.D., & Harrison, J.M. (1984) Reduction of blood loss in knee arthroplasty. Australia New Zealand Journal of Surgery. 54(2), 141-144.
- Sehat, K.R., Evans, R., & Newman, J.H. (2003). How much blood is really lost in total knee arthroplasty?. Correct blood loss management should take hidden loss into account. The Knee. 7(3), 151-155.
- Sehat, K.R., Evans, R.L., & Newman, J.H. (2004). Hidden blood loss following hip and knee arthroplasty. Correct management of blood loss should take hidden loss into account. Journal of Bone and Joint Surgery. 86(4), 561-565.
- Kumar, S.G., Von Arx, O.A., & Pozo, J.L. (2005). Rate of blood loss over 4bid8 hours following total knee replacement. The Knee. 12(4), 307-309.

- Spahn, D.R. (2010). Anemia and Patient Blood Management in Hip and Knee Surgery: A Systematic Review of the Literature. Anesthesiology, 113(2), 482-495.
- Wang, X., Rintala, D.H., Garber, S.L., & Henson, H. (2005). Association of hemoglobin levels, acute hemoglobin decrease, age, and co-morbidities with rehabilitation outcomes after total knee replacement. American Journal of Physical Medicine & Rehabilitation. 84(6), 451–456.
- Cavenaghi, F., Cerri, C., & Panella L. (2009) Association of hemoglobin levels, acute hemoglobin decrease and age with Rehabilitation outcomes after total hip and knee replacement. European Journal of Physical and Rehabilitation Medicine. 45(3), 319-325.
- So-Osman, C., Nelissen, R., Brand, R., Brand, A., & Stiggelbout, A.M. (2011). Postoperative anemia after joint replacement surgery is not related to quality of life during the first two weeks postoperatively. Transfusion. 51(1), 71-81.
- Vuille-Lessard, E., Boudreault, D., Girard, F., Ruel, M., Chagnon, M., & Hardy, J.F. (2012). Postoperative anemia does not impede functional outcome and quality of life early after hip and knee arthroplasties. Transfusion. 52(2), 261-270.
- Hoogeboom, T.J., van Meeteren, N.L.U., Schank, K., Kim, R.H., Miner, T., & Stevens-Lapsley, J.E. (2015). Risk Factors for Delayed Inpatient Functional Recovery after Total Knee Arthroplasty. Biomed Research International. 2015, 1-5.
- Bidolegui, F., Arce, G., Lugones, A., Periera, S., & Vindver, G. (2014). Tranexamic Acid Reduces Blood Loss and Transfusion in Patients Undergoing Total Knee Arthroplasty without Tourniquet: A Prospective Randomized Controlled Trial. Open Orthopaedics Journal. 8, 250-254.
- Vamvakas, E.C., & Blajchman, M.A. (2009). Transfusion-related mortality: the ongoing risks of allogeneic blood transfusion and the available strategies for their prevention. Blood. 113(15), 3406-3417.
- Sinnatamby, C. (2011). Last's Anatomy: Regional and Applied 12ed. Churchill Livingston; Sydney.
- 18. Pallister CJ, & Watson, M.S. (2010). Haematology 2nd ed. Scion Publishing; Banbury.
- Blanie, A., Bellamy, L., Rhayem, Y., Flaujac, C., Samama, C.M., Fontenay, M., & Rosencher, N. (2013) Duration of Postoperative Fibrinolysis after Total Hip or Knee Replacement: A Laboratory Follow-up Study. Thrombosis Research.131, e6-e11.
- Singh, S., Gudzenko, V., & Fink, M.P. (2012) Pathophysiology of perioperative anaemia. Best Practice & Research Clinical Anaesthesiology. 26, 431–439.
- Zhang, Q., Guo, W., Zhang, Q., Liu, Z., Cheng, L., & Li, Z. (2011) Comparison Between Closed Suction Drainage and Nondrainage in Total Knee Arthroplasty A Meta-Analysis. The Journal of Arthroplasty. 26(8), 1265-1272.
- Huang, Z.Y., Jun Ma, J., Pei, F., Yang, J., Zhou, Z. Kang, P., Shen, B. (2013). Meta-analysis of Temporary Versus No Clamping in TKA. Orthopedics. 36(7), 543-550.
- Li, T., Zhuang, Q., Weng, X., Zhou, L., & Bian, Y. (2014). Non-continuous versus continuous wound drainage after total knee arthroplasty: a meta-analysis. International Orthopaedics. 38, 361-371.
- Wakankar, H.M., Nicholl, J.E., Koka, R., D'Arcy, J.C. (1999). The tourniquet in total knee arthroplasty: A Prospective, randomised study. The Journal of Bone and Joint Surgery. 81-B(1), 30-33.
- Alsaleh, K., Alotaibi, G.S., Almodaimegh, H.S., Aleem, A.A., & Kouroukis, T. (2013). The Use of Preoperative Erythropoiesis-Stimulating Agents (ESAs) in Patients Who Underwent Knee or Hip Arthroplasty A Meta-Analysis of Randomized Clinical Trials. The Journal of Arthroplasty. 28, 1463-1472.
- Yang, T.Q., Geng, X.L., Ding, M.C., Yang, M.X., & Zhang, Q. (2014). The efficacy of fibrin sealant in knee surgery: A meta-analysis. Orthopaedics & Traumatology: Surgery & Research. 101, 331–339.
- Sutton, P.M., Cresswell, T., Livesey, J.P., Speed, K., & Bagga, T. (2004). Treatment of anaemia after joint replacement: A double-blind, randomised, controlled trial of ferrous sulphate versus placebo. The Journal of Bone and Joint Surgery. 86-B(1), 31-33.
- Liu, Z. & Yang, H. (2011). Comparison of the Minimally Invasive and Standard Medial Parapatellar Approaches for Total Knee Arthroplasty: Systematic Review and Meta-analysis. The Journal of International Medical Research. 39, 1607 – 1617.
- Teng, Y., Du, W., Jin, J., Gao, X., Pan, S., Wang, J. An, L., Ma, J., & Xia, Y. (2012). Subvastus Versus Medial Parapatellar Approach in Total Knee Arthroplasty: Metaanalysis. Orthopedics. 35(12), e1722-e1731.
- Xu, S., Lin, X., Tong, X., & Wang, X. (2014). Minimally Invasive Midvastus versus Standard Parapatellar Approach in Total Knee Arthroplasty: A Meta-Analysis of Randomized Controlled Trials. PLoS One. 9(5), e95311.
- Voleti, P.B., Hamula, M.J., Baldwin, K.D., & Lee, G. (2014). Current Data Do Not Support Routine Use of Patient-Specific Instrumentation in Total Knee Arthroplasty. The Journal of Arthroplasty. 29, 1709-1712.

- Xie, C., Kai Liu, K., Luxin Xiao, L., & Tang, R. (2012). Clinical Outcomes After Computer-assisted Versus Conventional Total Knee Arthroplasty. Orthopedics. 35(5), e647-e653.
- Paul, E.D., Ling, E., Lalonde, C., & Thabane, L. (2007). Deliberate hypotension in orthopedic surgery reduces blood loss and transfusion requirements: a metaanalysis of randomized controlled trials. Canadian Journal of Anaesthesia. 54(10), 799-810.
- Adie, S., Naylor, J.M., & Harris, I.A. (2010). Cryotherapy After Total Knee Arthroplasty A Systematic Review and Meta-Analysis of Randomized Controlled Trials. The Journal of Arthoplasty. 25(5), 709-715.
- Macfarlane, A.J.R., Prasad, G.A., Chan, V.W.S., & Brull, R. (2009) Does Regional Anesthesia Improve Outcome After Total Knee Arthroplasty? Clinical Orthopaedics and Related Research. 467, 2379–2402.
- Ker, K., Edwards, P., Perel, P., Shakur, H., & Roberts, R. (2012). Effect of Tranexamic acid on surgical bleeding: systematic review and cumulative metaanalysis. British Medical Journal. 344(e3054), 1-13.
- Yang, Z., Chen, W., & Wu, L. (2012). Effectiveness and Safety of Tranexamic Acid in Reducing Blood Loss in Total Knee Arthroplasty: A Meta-Analysis. The Journal of Bone and Joint Surgery. 94-A(13), 1153-1159.
- Tan, J., Chen, H., Liu, Q., Chen, C., Huang, W. (2013). A meta-analysis of the effectiveness and safety of using Tranexamic acid in primary unilateral total knee arthroplasty. Journal of Surgical Research. 184, 880-887.
- Soni, A., Saini, R., Gulati, A., Paul, Rajesh, Bhatty, S., & Rajoli, S.R. (2014) Comparison between intravenous and intra-articular regimens of Tranexamic acid in reducing blood loss during total knee arthroplasty. The Journal of Arthroplasty. 29, 1525-1527

- Alshryda, S., Mason, J., Vaghela, M., Sarda, P., Nargol, A., Maheswaran, S., Tulloch, C., Anand, S., Logishetty, R., Stothart, B., & Hungin, A.P.S. (2013). Topica-Tranexamic Acid Reduces Blood Los and Transfusion Rates Following Total Knee Replacement: A Randomized Controlled Trial (TRANX-K). The Journal of Bone and Joint Surgery. 95, 1961-1968.
- Gomez-Barrena, E., Ortega-Andreu, M., Padilla-Eguiluz, N., Perez-Chrzanowska, H., & Figueredo-Zalve, R. (2014). Topical Intra-articular compared with intravenous tranexamic acid to reduce blood loss in primary total knee replacement: A double-blind, Randomized, Controlled, Noninferiority Clinical Trial. The Journal of Bone and Joint Surgery. 96, 1937-1944.
- Lin, S.Y., Chen, C.H., Fu, Y.C., Huang, P.J., Chang, J.K., & Huang, H.T. The efficacy of combined use of intraarticular and intravenous tranexamic Acid on reducing blood loss and transfusion rate in total knee arthroplasty. The Journal of Arthroplasty. 30(5), 776-780.
- Harvey, I.A., Barry, K., Kirby, S.P.J., Johnson, R., & Elloy, M.A. (1993). Factors Affecting the Range of Movement of Total Knee Arthroplasty. The Journal of Bone and Joint Surgery. 75-B (6), 950-955.
- Erbert, J.R., Munsie, C., & Joss, B (2014). Guidelines for the Early Restoration of Active Knee Flexion After Total Knee Arthroplasty: Implications for Rehabilitation and Early Intervention. Archives of Physical Medicine and Rehabilitation. 95, 1135-1140.
- 45. Exuzides, A., Colby, C., Goldman, J., & Waaler. A. (2009, October). Reducing bias in a retrospective case-control study: An application of propensity score matching. Presented at the ISPOR 12th Annual European Congress; Paris, France.
- 46. Parry, M., Wylde, V., & Blom, A. (2011). Early death following primary total knee replacement. The Journal of Bone and Joint Surgery. 93-A(10), 953-948.

Tissue Sparing Total Hip Arthroplasty Study Group

The Joint Implant Surgery and Research Foundation has a long history in the study of THA. It began back in 1971 when Professor Charles O. Bechtol, M.D. established JISRF as a nonprofit scientific and educational foundation.

JISRF continues this study with the formation of a new study group of international surgeons and scientists. Findings will be posted on the foundation's web site at <u>www.jisrf.org</u>.

Joint Implant Surgery and Research Foundation 46 Chagrin Shopping Plaza, #117 • Chagrin Falls, OH 44022



Surgeons interested in learning more contact the Executive Director at www.JISRF.org



Reconstructive REVIEW



ORIGINAL ARTICLE

http://dx.doi.org/10.15438/rr.6.2.140

Our Experience with Short Stem Hip Replacement Surgery

Rastogi S¹, Marya S¹

Abstract

Context: A short anatomical metaphyseal femoral stem is a desirable hip implant for bone and soft tissue preserving hip replacing surgery in young active patients. Physiological loading of the proximal femur prevents stress shielding and preserves bone stock of the femur in the long run. Thus it is an ideal hip implant suited for conservative hip surgeries in young adults with arthritic hips.

Materials and Methods: 50 Proxima hip replacements were performed on 41 patients with a mean age of 45 over a 3-year period (between July 2006 and September 2009). Diagnosis of hip pathologies varied from osteoarthritis secondary to avascular necrosis, rheumatoid arthritis, post-tubercular arthritis to dysplastic hips. 9 of these patients had symptomatic bilateral hip involvement and underwent bilateral hip replacement in a single sitting. All patient had a Proxima metaphyseal stem implantation with either a large diameter metal on metal or pinnacle articulation. Clinical and radiological evaluation was done at 3 months, 6 months, 1 year and then yearly

Statiscal Analysis Used: VAS and Harris hip score formed the basis of evaluation

Results: These patients were followed up for a mean period of 49 months (Range 36-72 months). The average incision size was 14.38 cm (10-18 cm) and blood loss was 269 ml (175-450 ml). There was no peri-operative mortality or serious morbidity in any patients. One patient had an intraoperative lateral cortex crack that required only delayed rehabilitation. Five of the 41 patients (12.1 %) had complications with three recovering completely and one requiring revision of femoral stem for aseptic loosening. One patient was lost in follow-up. Harris hip score improved from 52 to 89.3 at last follow-up. Overall 95.1% (39/41) patients had an excellent outcome at last follow-up.

Conclusion: We conclude that Proxima metaphyseal stem provided clinically and radiologically stable fixation through snug fit initially followed by bone in-growth and was ideally suited to satisfy the requirements of a conservative hip implant. Unfortunately, due to unknown reasons, the implant has been recently withdrawn from the market by DePuy and is no longer available for use.

Key Message: Conservative hip stems that preserve bone and soft tissue at the time of surgery, prevent

1 Dr. Sumeet Rastogi MBBS, DNB (Ortho), Dr. S K S Marya, MBBS, MS, DNB (Ortho)

Max Institute Of Musculoskeletal Sciences No 1, Press Enclave Road, Saket, New Delhi, India (Direct reprint requests to Sumeet Rastogi) Authors retain copyright and grant the journal right of first publication with the work. Reconstructive Review follows the <u>Creative Commons Attribution-NonCommercial</u> <u>CC BY-NC</u>. This license allows anyone to download works, build upon the material, and share them with others for non-commercial purposes as long as they credit the senior author, Reconstructive Review, and the Joint Implant Surgery & Research Foundation (JISRF). An example credit would be: "Courtesy of (senior author's name), Reconstructive Review, JISRF, Chagrin Falls, Ohio".

^{© 2016} Rastogi, Marya. All rights reserved.

femoral stress shielding by circumferential loading, promote positive bone remodeling and help to make revision surgeries easier are ideal suited as hip implants for young active adults with end stage hip disease requiring hip replacement surgery.

Keywords: total hip replacement, uncemented, conservative, metaphyseal stems, Proxima. *Level of Evidence:* AAOS Therapeutic Level IV

Introduction

Over the last two decades, the profile of the patient requiring hip replacement surgery has changed dramatically. Increasingly, more young and active patients with end stage hip disease are seeking hip replacement surgery. This change in the demographic profile of the patient has put an increased demand on the orthopaedic surgeons to conduct bone preserving surgeries especially keeping in mind the higher incidence of expected revision surgery in this age group. They realize that implants need to be designed so that they not only conserve bone and soft tissue but also are able to withstand the vigorous and demanding lifestyle of this age group.

Surgeons have largely opened up to the idea of uncemented hips. Substantial progress has been made in this area but a number of limitations remain, particularly with respect to bone preservation, stress shielding, thigh pain and revision surgery.

Anatomical metaphyseal stems are ideally poised to address these shortcomings. Bone and soft tissues sparing in approach, they promote more physiological loading of the proximal femur thus preserving bone strength and preventing stress shielding. Active bone ingrowth into the structured surface of stem provides both early and sustained bony fixation.

Research has been directed towards creating a modern femoral implant that is anatomical in shape, preserves healthy femoral bone during implantation, loads the neck and metaphyses in a near physiological manner and creates a biomechanically favorable offset while minimizing soft tissue handling.

Material And Methods

50 Proxima hip replacements were performed on 41 patients by the senior author between July 2006 and September 2009. This group included 25 males and 16 females. The average age of the patients at the time of surgery was 45 years (range 35 years to 55 years). The diagnosis in 30 patients was osteoarthritis secondary to avascular necrosis, three patients had post-traumatic arthritis, three ankylosing spondylitis, three rheumatoid arthritis, one post tubercular arthritis and one had osteoarthritis secondary to a dysplastic hip. Out of the total of 41 patients, nine patients had bilateral hip involvement that was symptomatic and underwent bilateral hip replacement in the same sitting. All the patients were ambulatory when they presented for surgery. They were walking unaided or with support (cane or walker). A few of the patients had comorbidities such as HT, DM, CAD and CKD (14 out of 41).

All the patients were followed up until September 2012, the average duration of follow-up being 49 months (range 36-72 months) with minimum duration of follow-up of 3 years.

General Measurements:

The Harris hip score and VAS (Visual analogue score) were used to assess clinical outcome.

Evaluation:

All patients were subject to pre and post-operative clinical and radiological evaluation. This was done before and immediately after surgery, at 6 weeks, at 3 months, 6 months, 12 months and yearly interval thereafter.

Clinical evaluation:

General demographic data such as age, height and weight was noted. Additional information about the diagnosis, condition of the joint, movements, shortening and co-morbid conditions was recorded. Baseline Harris hip and VAS was also recorded.

The surgical approach, average surgical time, blood loss, details of any intra operative or peri-operative complications, incision length and implant sizes were recorded.

Radiological evaluation:

X rays of the affected hips were done at each checkup. At each point standard AP & Lateral radiographs of the affected hip were taken. The femur was evaluated for signs of radiolucencies, osteolysis, subsidence, stem migration, stress shielding, bone remodeling and heterotrophic ossification. Similarly, the acetabular component was evaluated for radiolucencies, areas of osteolysis and migration/ protrusio.

Surgical technique:

Per-operatively, with the patient in a lateral position, the hip joint was exposed either through a posterior-lateral approach or a modified anterior-lateral approach. Af-

HART	– patient detai	us					
ID NO	AGE/SEX	D/O	CO-MOR	APP/INC	BD LOSS	PO MORBIDITY	FWB
A01	54/M	OA	HT	PL-17	375	-	3
A02	45/F	OA B/L	-	PL-15/14	325	-	3
A03	37/F	OA	-	PL-12	275	-	3
A04	48/M	OA	DM	PL-14	400	Lateral Cortex fracture	4
A05	51/M	OA	HT	PL-15	325	-	3
A06	47/M	OA B/L	-	PL-15/16	400	Anemia	3
A07	55/M	OA	CAD	PL-17	300	-	3
A08	39/F	RA	HT	PL-18	375	Anemia	3
A09	49/F	OA	-	AL-15	290	-	3
A10	42/M	AS	HT	AL-15	400	-	3
A11	39/M	OA B/L	-	AL-17/16	300	-	3
A12	35/F	OA	-	AL-13	300	-	3
A13	45/F	OA	-	AL-14	250	-	4
A14	40/M	PTA	-	AL-15	375	Electrolyte Imb	3
A15	39/F	PTUBA	-	AL-16	450	Anemia	3
A16	48/M	OA	DM/HT	AL-15	300	-	3
A17	42/M	OA B/L	-	AL-14/14	315	-	3
A18	46/M	OA B/L	-	AL-13/14	330	Anemia	3
A19	39/M	OA	-	AL-10	400	-	4
A20	47/F	OA	CKD/HT	AL-12	415	Anemia	3
A21	49/M	AS	HT	AL-14	350	-	4
A22	50/M	РТА	-	AL-16	300	-	3 1/2
A23	39/M	OA	-	AL-13	175	-	3
A24	41/F	RA B/L	-	AL-12/13	375	Anemia/HT	4
A25	51/F	OA	HT/HYPO	AL-14	200	-	3
A26	49/M	OA	HT	AL-12	300	-	3
A27	41/F	PTA	-	AL-15	350	-	3
A28	48/M	OA	BHP/HT	AL-12	290	-	3
A29	39/M	OA	-	AL-12	325	-	3
A30	41/F	OA	-	AL-16	300	-	3
A31	52/M	OA B/L	-	AL-16/16	325	-	3
A32	49/M	OA	-	AL-14	400	-	3
A33	40/F	DYS	-	AL-15	290	-	3 1/2
A34	48/F	OA B/L	-	AL-17/16	325	Anemia	3
A35	44/F	OA	-	AL-16	390	-	3
A36	39/M	AS	-	AL-15	275	-	3
A37	51/M	OA	-	AL-11	300	-	3
A38	54/M	OA B/L	-	AL-15/14	325	-	3
A39	42/F	RA	HT/DM	AL-13	340	Anemia/Hypotension	4
A40	50/M	OA	-	AL-12	275	-	3 1/2
A41	45/M	OA	HT	AL-14	300	-	3
	1	1		1	1	j.	

D/O: diagnosis, CO-MOR: comorbidity, APP/INC: approach/ incision length cm, BD: blood in ml

PO: perioperative, FWB: full weight bearing, HT: hypertension, DM: diabetes mellitus

CAD: coronary artery disease, HYPO: hypothyrodism, CKD: chronic kidney disease DYS: Dysplasia ter the hip was dislocated, the neck was osteotomised high at the base of head with full preservation of femoral neck. To prevent damage to greater trochanter-abductor complex and Gluteus medius muscle, a "Round the corner" technique had been used for broaching the femoral canal [1]. In this technique, the broaching and final implant insertion is done with a slight curved movement of the insertion handle. The broach is first introduced in varus position and then gradually bought to neutral position as broaching progresses. Specially designed broaches have been developed for this technique (Fig 1a and 1b). These broaches are anatomic and side specific. Alignment of the broach in the femur can be checked at any step by using an external alignment rod on the insertion handle. The definitive implant insertion is done in a similar fashion (Fig 2).

The femoral implant used was a Proxima metaphyseal stem (DePuy, USA) with either a large diameter metal on metal or Pinnacle metal on poly articulation (DePuy, USA).



Figure 1a and 1b. Specially designed side specific broaches used for reaming the femur.



Figure 2. Intraoperative photo of proxima metaphyseal stem just before implantation

Postoperatively, all patients were kept in High Dependency Unit for one day for observation. Prophylactic intravenous antibiotics were used for 2 days and followed by oral antibiotics for another 5 days. On the 1st POD, routine blood investigations like haemogram and renal function were re-evaluated and blood was transfused if required. Suction drains were removed 24 hours after surgery and epidural catheters after 48 hours. All indwelt catheters were removed by 48 to 72 hours (after discontinuation of epidural anesthesia). All patients were kept on physical (foot and calf pumps) and chemical prophylaxis against DVT during their hospital stay.

Physiotherapy in the postoperative period involved static exercises in bed, side turning and bedside sitting on the first postoperative day. Mobilization with partial weight bearing with walker was started from the 2nd POD. Walker aided ambulation was continued for the next six weeks. Progression to full weight bearing and stick support was done gradually after six weeks following a clinical and radiological examination. Active hip mobilization, abductor and quadriceps strengthening exercises were continued. Supervised physiotherapy at home was usually continued for four to six weeks after surgery.

At three months, the ability of the patients to walk without support, squat and sit cross-legged was also assessed. If they satisfactorily performed these activities, they were allowed to progress to advanced activities such as swimming and golfing.

Results

The results were graded as excellent, good or poor on a simplified score based on parameters like VAS score, Harris hip score, return to normal and advanced hip function.

The first Proxima hip replacement was done by the senior author in July 2006. We report our experience with the first 50 such hip replacements using a Proxima metaphyseal stem on 41 patients. There were 25 males and 16 females in the study group. Nine of the 41 patients underwent bilateral hip replacement in a single sitting (Figure 3). The average age of the patient at the time of surgery was 45 years (range 35 to 55 years). The patients had a mean weight of 72 kgs. (Range 65 – 95 kgs.). 14 patients had associated co-morbidities like HT, DM, CAD and chronic kidney disease. The minimum duration of follow-up being 3 year. One patient was lost in the follow-up study period.

The implant used was a Proxima metaphyseal stem (DePuy, USA) with either a large diameter metal on metal XL or Pinnacle Metal on poly articulation (DePuy, USA). The first eight patients were operated through a posterio-

Result Grading						
Grading	Harris Hip Score	Return Te Basic Hip	0	Return Advanc	To ed Hip	Vas 3 Mths
Result		Functi	on	Func	Function	
		Unaided Driving	Car	Sitting	Light	
		Walking		Cross-L Sports	egged	
Excellent	90	Yes	Yes	Yes	Yes	0-1
Good	80-90	Yes	No	Yes	No	2
Poor	-80	No	No	No	No	3

Our Experience with Short Stem Hip Replacement Surgery 25

Result C	Chart
----------	-------



Figure 3. Preoperative and postoperative x-ray of a bilateral secondary hip osteoarthritis patient who underwent a bilateral hip replacement in the same sitting

lateral approach while remaining 33 were approached through an anterior-lateral approach. The incision size varied from 10 cm to 18 cm with an average of 14.38 cm. The average post-operative blood loss for each hip was 269 ml (range 175ml - 450 ml). The mean Harris hip score before surgery was 52 (range 25–62), at 3 months was 75, at one year was 85.8 at last follow up was 89.3 (range 86–91). The average VAS score at 3 months was 0.85 (0-3 range). All but 2 patients at three months follow-up achieved full weight bearing status without support. 39 of the 41 operated cases (95.1%) showed excellent result at the last follow up with ability to walk without support, sit cross-legged, return to normal and advanced activities and had high satisfaction level with surgery.

ID NO	Follow up	VAS (3 Mo.)	Harris Hip Score (3 Mo.)	Harris Hip Score (12 Mo.)	Harris Hip Score (Last Follow up)
A01	49	2	74	84	89
A02	47	2	73	84	89
A03	56	0	80	89	91
A04	39	3	60	80	86
A05	45	1	68	77	88
A06	56	0	82	88	90
A07	57	2	69	81	88
A08	40	1	75	84	89
A09	36	1	79	85	89
A10	42	0	80	89	89
A11	47	3	75	64	89
A12	55	2	72	81	89
A13	60	1	80	88	90
A14	56	1	75	91	91
A15	44	0	80	89	90
A16	48	0	82	90	89
A17	57	1	80	90	90
A18	49	0	79	90	90
A19	40	1	69	88	89
A20	50	0	79	86	90
A21	37	0	82	89	91
A22	55	0	76	87	89
A23	49	3	73	84	88
A24	50	0	79	87	88
A25	44	0	76	86	89
A26	46	1	71	85	89
A27	50	0	77	88	90
A28	52	1	73	87	91
A29	59	2	70	82	90
A30	60	1	75	88	89
A31	48	0	79	89	90
A32	42	1	76	88	90
A33	38	1	78	89	89
A34	47	0	78	87	90
A35	40	1	72	84	89
A36	46	0	68	84	88
A37	38	2	69	86	89
A38	39	0	77	88	89
A39	45	0	75	86	90
A40	48	1	74	87	89
A41	40	0	78	90	90

VAS: visual analogue score

Five of our patients (12.1%) in this study group had some sort of complications from which 3 recovered completly. These included undisplaced lateral cortex fracture, post-traumatic fracture of greater trochanter, superficial infection, femoral stem migration and aseptic stem loosening requiring stem revision.

The first patient had an intra-operative lateral cortex fracture that was only diagnosed on postoperative x-rays. The femoral implant was otherwise in a good position. The patient was kept non-weight bearing with a walker for 6 weeks, sequential x-rays did not show any change in the stem positioning and then he was gradually allowed partial weight bearing. This patient made a satisfactory recovery.

The second patient developed pain around the hip about six weeks after surgery following a fall. X-rays showed an undisplaced fracture of the greater trochanter due to the fall. There was no displacement of the femoral prosthesis or acetabular component. He was treated conservatively with non-weight bearing and a hip abduction brace till the fracture healed fully on x-rays. However, he continued to have unexplained hip pain on walking. At one year, the pain continued to persist and he required stick support for walking. All investigations including repeated ESR, CRP, x-rays and bone scan were normal. Hip joint aspirate yielded a negative culture report. In the absence of relief with conservative treatment, we advised the patient revision hip surgery for which he refused. This patient had poor satisfaction with surgery.

The third patient was operated for bilateral hip avascular necrosis and developed insidious onset of pain in one of the operated hips nine months after surgery. Investigations, including a Tc99 bone scan showed aseptic loosening of the femoral stem of the involved side. The acetabular cup had no evidence of loosening. Conservative treatment did not relieve him of symptoms, hence he was taken up for resurgery and the Proxima stem was revised to a fully coated uncemented stem (Corail, DePuy, USA) 12 months after his primary surgery. Intra-operatively the cup did not show any evidence of loosening and was retained. Moreover this patient has no symptoms on the contra-lateral Proxima hip. At 12 months follow-up after re-surgery, the patient was walking without support but with a slight limp (abductor lurch) and demonstrated good ability to sit on the floor. At 2-year follow-up he had a completely normal gait and was actively participating in exertional activities. At a recently concluded 5 year follow-up, he continues to be ok with no radiological evidence of femoral or acetabular change in both hips (Fig 6).

The 4th patient developed stitch line discharge in the post-operative period. C/S of the discharge showed staph. growth that was treated with appropriate injectable antibi-

otics for 3 weeks. The discharge subsided and the patient made an uneventful recovery.

The last patient developed insidious femoral stem migration 3 years after the primary surgery. Investigations revealed aseptic loosening of stem for which she was advised revision surgery. We subsequently lost the patient in FU.

All 39 (95.1%) other patients continue to be satisfied with their functional outcome and none showed radiological evidence of acetabular or femoral component loosening, osteolysis or migration at last follow-up. (Figure 4, Figure 5, Figure 6)

After the withdrawal of large diameter metal on metal articulation, all patients having metal on metal cups implanted were intimated of the withdrawal and evaluated with estimation of serum cobalt and chromium levels and



Figure 4. Preoperative and postoperative x-rays of a patient with post-traumatic hip osteoarthritis (right side operated).



Figure 5. Preoperative and postoperative xrays of Proxima Replacement Following Fracture Acetabulum and x-rays after 1 year follow-up



MARS (metal artifact reduction) MRI scan of the hip (as per recommendation of the manufacturers). Yearly evaluation of these patients is being done. None of the patients are symptomatic and at last follow-up, their investigation reports were normal. These patients will continue to be monitored as per recommendations.

Discussion

Cemented hip replacement has been documented to give good results particularly in elderly patients in terms of relief of pain and restoration of function. However their results in younger patients are far from ideal particularly in terms of stress shielding and revision surgery. [2]

In 1987, Jones and Hungerford [3] coined the term "cement disease" to describe cement induced osteolysis affecting cemented hip components. Although proved a misnomer, it added considerable interest in the swing towards cementless hip replacement.

Initially cementless implants showed considerable promise by providing stable fixation. But gradually a new set of problems emerged. Stable distal fixation and distal offloading resulted in stress shielding and loss of proximal femoral bone stock [4, 5]. Kim et al [6] had published a report of 8 .8 years follow-up that showed significant stress shielding at the calcar in a distal metaphyseal load-bearing stem. Thigh pain also emerged as a major issue and usually correlated to the stem length [7].

Despite significant advances in understanding of tribiology, better materials and improved fixation, these problems continued to plague cementless hips. In fact when considering the efficacy of porous coated cementless stems, Amstutz in 1991 noted "the incidence of thigh pain, radiological stress shielding and removal problems must still be solved....." [19].

Until recently, Resurfacing arthroplasty was the only technique available to surgeons for treatment of arthritis of the hip that preserved the femoral head. However even then, there were concerns regarding the vascularity of the remaining femoral head and incidence of femoral neck fractures after surgery. Also there were a set of well defined contraindications to resurfacing that limited its applications. Moreover, recent reports of increased metal ions in the blood and subsequent formation of pseudo-granulomas after their use has lead to the withdrawal of resurfacing prosthesis from the market.

The last 2 decades have shown a considerable change in the demographic profile of patients that are presenting for hip replacement surgery. Today's generation of patient demand much more from their replaced hips, particularly the ability to indulge in recreational activities and contact sports. Their hips are consequently exposed to considerably increased levels of stress. Hip implants thus need to be conservative with regards to bone and soft tissue insult, should be able to withstand the increased stresses placed upon them and last longer while making revision surgeries easier.

This fundamental shift towards the principle of reduced bone and soft tissue violation and the fact that an increased number of young patients are undergoing primary and revision hip surgery affords significant importance to bone preserving prosthesis.

In 1917, John C Koch [8] proposed his model of the

mechanics of loading of the hip. In this model, he assigned compressive and tensile forces along the medial and lateral femoral surfaces. Fatto et al [9] further refined this model in 1995 and showed that the lateral femoral cortex can be effectively used to carry compressive loads. Leari et al [10] reviewed radiographs of primary THR with a lateral flare for axial migration and stability. They concluded that a prominent lateral flare provided significant initial stability through early bony ingrowth, which is vital for long term implant stability and provision against stress shielding. Interestingly, in 1993 Jasty et al [11] had proved that the diaphyseal portion of femoral stem is not required for implant stability once stable proximal fixation was achieved.

Thus in the absence of diaphyseal stem fixation, proximal load transfer through a anatomical lateral flare is an essential pre-requisite for best performance of an uncemented femoral stem in primary THR.

Classification

With so many short stems with significant variation in geometry and philosophy in the market, a simplified classification system was proposed by The Joint Implant Surgery and Research Foundation (JISRF). It basically classifies short stems under 4 groups [20].

- Head Stabilized: now discontinued. It included A. Hip Resurfacing B. Mid-Head resection Stem
- 2. Neck Stabilized: a variety of neck stabilizing hip plugs, also called neck arthroplasty device by some surgeons, are now available. With minimal metaphyseal engagement, they are purely designed to sit in the femoral neck. This is one of the fastest growing market segments for short stems. Historically, femoral neck retention was advocated by Freeman, Townley, Whiteside and Pipino. Only Pipino advocated a short curved neck-sparing stem. The ring of cortical bone saved in the neck-sparing stem has significant bio-mechanical advantage. Pipino refered to this as a "tension band".

A. Short Curved StemsB. Short Lateral Engaging StemC. Neck Plugs or Neck Only

3. Metaphyseal Stabilized: There is a long history of using short metaphyseal stems that include anatomical, straight, and tapered style stems. Variable results have been seen often depending on implant design, surgical technique, bone quality and patient related activities

A. Taper Stems B. Bulky/Fit and Fill Stems

4. Conventional Metaphyseal/Diaphyseal Stabilized

Metaphyseal stems have been in use since 1978 when Huggler and Jacobs [12] designed the Thrust plate prosthesis (TPP). Buergi, Huggler and Ishaqui have all reported good to excellent mid term results with the Thrust plate prosthesis [13,14,15]. Early metaphseal stems like Mayo, Nanos and Metha stems represented the next generation of design based on the common principle of reduced femoral violation, non anatomic geometry, proximal calcar loading and lateral alignment in the presence of a shortened diaphyseal stem [16]. Radiological studies showed condensation of bone in the metaphyses and proximal diaphyses indicating early and stable biological fixation and the absence of stress shielding. Studies by various other authors have shown good to excellent results with these stems.

The IPS [17] (Immediate post operative stability) stem was a metaphseal filling anatomical stem launched in 1999 by DePuy. It had a distal diaphyseal extension used only for the purpose of stem alignment. It was designed to provide immediate post-operative stability within the proximal region of femur.

Based on the modified principle of femoral biomechanics by Fetto [9], F.S. Santori with his team at Stanmore customs designed and developed his custom metaphyseal stem in 1995, which he further modified in 1999 by entirely removing the distal stem. There were concerns that without distal fixation, the stem was susceptible to torsional strain, varus tilt and distal migration. However, as shown by Whiteside [18], a high neck cut prevents micromotion and provides rotational stability. The stem profile is anatomic and creates a wedging effect between proximal medial femur and lateral flare preventing distal stem migration. Santori has shown excellent clinical and radiological results and positive bone remodeling with this implant putting to rest the doubts raised about the functional efficacy of his implant [1].

Based on the principle of proximal load transfer and drawing its heritage from two previous uncemented stem, the IPS stem and Santori's custom stem, the proxima metaphyseal stem (DePuy, USA) was developed by an international team of surgeons.

Designed as a short uncemented, anatomic, metaphyseal stem, the Proxima stem was ideally poised to fulfill the demand for a conservative hip implant. It preserved the calcar area of the neck, maintained the integrity of the trochanteric area and attached abductor group of muscles and utilized the cancellous bone of the proximal femur to provide stable and durable biological fixation. With well defined medial and lateral trochanteric flares and absence of distal stem, it lend itself to minimally invasive surgery. This resulted in reduced soft tissue violation, less bone loss, accelerated rehabilitation and positive bone remodeling. Also due to its unique design features, it loaded the proximal femur most physiologically thus prevented stress shielding and increased available bone stock for future use.

Excellent studies by Santori, Learmonth and various other authors have shown that Proxima stem provided stable, predictable and durable biological fixation, reduced stress shielding and excellent remodeling [1,17].

Another significant benefit expected from this short stem was in cases of revision surgery. It allowed for a conservative revision option in case of a failed conservative implant such as resurfacing prosthesis. Also in cases of its failure, as we have experienced, it could be easily revised and replaced with a traditional uncemented femoral stem with minimal bone loss [16].

Conclusion

In conclusion it can be expected that the future of hip stems may lie in a short anatomical stem that mimics the replaced femoral bone in every possible aspect, especially physiologically and biomechanically, minimizes violation of bony and soft tissue and provides for maximum available good quality bone stock for future use. Published results with this stem have been very encouraging and our own experience with this implant has strengthened this belief. Unfortunately, due to unknown reasons, the implant has been recently withdrawn from the market by DePuy and is no longer available for use. We shall however continue to follow all our operated cases in future, as we believe that this was the ideal implant for conservative hip surgeries and the future lies in this direction.

Disclosure

The authors declare that there is no conflict of interest regarding the publication of this paper. For full disclosures refer to last page of this journal.

Referances:

- Santori FS, Manilim, Fredella N, Ottieri Tonci M, Santori N- ultra shot stem with proximal load transfer – Clinical & radiological results at 5 years follow up. Hip international / volume 16, no 1(Suppl 3), 2006: s31-s39
- Dorr LD, Kane TJ 3rd, Conaty JP. Long term results of cemented hip arthroplasty in patients 45 years old or younger. A 16 year followup study. J Arthroplasty 1995;10:255-6.
- 3. Jones LC, Hungerford DS. Cement disease. Clin Orthop 1987; 225(Dec):192-206.
- Engh CA, Bobyn JD, Glassman AH. Porous coated hip replacement. The factors governing bone ingrowth, stress shielding and clinical results. J Bone Joint Surg Br 1987; 69: 44-55.
- Malchau H, Herberts P, Wang YX, Karlholm J, Romanus B. long term clinical and Radiological results of lord total hip prosthesis. A prospective study. J Bone Joint Surg Br 1986; 78: 884-91.
- Kim YH. The results of a proximally coated cementless femoral component in total hip replacement: a five to 12 year follow-up. J Bone Joint Surg. 2008; 90-B: 299–305.
- Vresilovic EJ, Hozack WJ, Rothman RH: incidence of thigh pain after uncemented total hip arthroplasty as a function of femoral stem size. J Arthroplasty 1996; 11: 304- 311.
- 8. Koch JC: the laws of bone architecture. Am J Anat 1917; 21: 177 298.
- Fetto JF, Bettinger P, Austin KS: re examination of hip biomechanics during unilateral stance Am J Orthop 1995; 8: 605 – 612.
- Leali A, Fetto J, Insler H, Elfenbein D: the effect of a lateral flare feature on implant stability Int. Orthop 2002; 26: 166 – 169.
- Jasty M, Krushell R, Zalenski E, O Connor D, Sedlacek R, Harris W (1993). the contribution of the non porous distal stem in the stability of proximally porous coated canine femoral components. J Arthroplasty 8 (1): 33 – 41.
- Huggler AH, Jacob HA. A new approach towards hip prosthesis design. Arch Orthop trauma Surg 1980; 97: 141 – 144.
- Buergi ML, Stoffel KK, Jacob HA, Bereiter HH. Radiological findings and clinical results of 102 Thrust plate femoral hip prosthesis. A follow-up of 2 to 8 years. J Arthroplasty 2005; 20:108-17.
- Huggler AH, Jacob HA, Bereiter H, Haferkom M, Ryf C, Schenk R. Long term term results with uncemented thurst plate prosthesis. Acta Orthop Belg 1993; 59 (supl 1): 215-23.
- Ishaque BA, Weinbeck S, Struz H. Midterm results and revision of thurst plate prosthesis. Z Orthop Ihre Grenzgeb 2004; 142:25-32. 21
- Falez F, Casella F, Panegroosi F, Favetti F, Barresi C. Perspective on metaphyseal conservative stems. J Orthop Traumatol 2008 March; 9(1):49-54.
- Learmonth Ian D. Conservative hip implants. Current orthopedics (2005); 19:255-262.
- Whiteside LA, White SE, McCarthy DS (1995) effect of neck resection on torsional stability of cementless total hip replacement. Am J Orthop (10): 766 – 770.
- Amstutz HC, Namba R. Cementless femoral fixation using porous ingrowth fixation. In: Amstutz HC, editor. Hip arthroplasty. New York: Churchill Livingstone; 1991; p: 285-293.
- McTighe T, Brazil D, Keggi JM, Keppler L, McPherson EJ. "Short-stem Designs for Total Hip Arthroplasty: Neck Stabilized Femoral Components" In book: The Adult Hip "Hip Arthroplasty Surgery" Third Edition, Chapter 64, Publisher: Wolters Kluwer, Editors: John J. Callaghan, Aaron G. Rosenberg, Harry E. Rubash, John C. Clohisy, Paul E. Beaule, Craig J. Della Valle, pp.823-849.



International Congress for Joint Reconstruction

Global

REGISTER NOW! Abstract Submission Deadline Extended To July 16, 2016

2016 Transatlantic Orthopaedic Congress

17TH ANNUAL ISK SPORTS MEDICINE & TOTAL KNEE & HIP COURSE IN COLLABORATION WITH THE EUROPEAN KNEE SOCIETY

New York, New York | October 6-9, 2016

www.icjr.net/2016transatlantic | info@icjr.net | +1-760-942-7859

CONGRESS HIGHLIGHTS:

- In collaboration with the European Knee Society
- An engaging curriculum with live surgeries and surgical vignettes, didactic and case-based presentations, interactive panel discussions, and debates
- Faculty of orthopaedic experts from Europe and the United States
- An intensive and comprehensive orthopaedic learning experience
- Bonus featured symposium on topics that matter today Enhanced Recovery and Comprehensive Care for Joint Replacement (CJR)
- Great time of year to be in New York with the fall weather

CONGRESS CO-CHAIRMEN



JEAN-NOËL ARGENSON, MD, PhD Marseille, France



W. NORMAN SCOTT, MD, FACS New York, NY, USA CONGRESS DIRECTORS

RICHARD IORIO, MD New York, NY, USA

WILLIAM J. LONG, MD, FRCSC New York, NY, USA

EMMANUEL THIENPONT, MD Brussels, Belgium







PERSONAL



PORTABLE

MAKE ICJR YOUR SOURCE FOR ORTHOPAEDIC EDUCATION AT WWW.ICJR.NET



REGISTER



Reconstructive REVIEW



CASE REPORT

http://dx.doi.org/10.15438/rr.6.2.145

Quadriceps Tendon Rupture and Contralateral Patella Tendon Avulsion Post Primary Bilateral Total Knee Arthroplasty: A Case Report

Sharma G¹, Bagaria V¹, Nadange S¹, Waghchoure C¹, Shah S¹, Tangirala R¹, Wadia F¹

Abstract

Background: Extensor mechanism failure secondary to knee replacement could be due to tibial tubercle avulsion, Patellar tendon rupture, patellar fracture or quadriceps tendon rupture. An incidence of Patella tendon rupture of 0.17% and Quadriceps tendon rupture of around 0.1% has been reported after Total knee arthroplasty. These are considered a devastating complication that substantially affects the clinical results and are challenging situations to treat with surgery being the mainstay of the treatment. Case Description: We report here an interesting case of a patellar tendon rupture of one knee and Quadriceps tendon rupture of the contralateral knee following simultaneous bilateral knee replacement in a case of inflammatory arthritis patient. End to end repair for Quadriceps tear and augmentation with Autologous Hamstring tendon graft was done for Patella tendon rupture.

Outcome: Patient was followed up for a period of 1 year and there was no Extension lag with a flexion of 100 degrees in both the knees.

Discussion: The key learning points and important aspects of diagnosing these injuries early and the management techniques are described in this unique case of bilateral extensor mechanism disruption following knee replacements.

Keywords: extensor mechanism, knee replacement, tendon injury Level of Evidence: AAOS Therapeutic Level IV

 Dr Gaurav Sharma, M.S.Orthopaedics, Dr Vaibhav Bagaria, M.S.Orthopaedics, Dr Shyam Nadange, DNB Orthopaedics, Dr Chaitanya Waghchoure, M.S.Orthopaedics, Dr Smit Shah, D.Ortho, M.S.Ortho, DNB Orthopaedics, Dr Ravishanker Tangirala, M.S.Orthopaedics, Dr Farokh Wadia, F.R.C.S., M.S.Orthopaedics (Direct reprint requests to Vaibhav Bagaria) @ 2016 Sharma, Bagaria, Nadange, Waghchoure, Shah, Tangirala, Wadia. All rights reserved.

Authors retain copyright and grant the journal right of first publication with the work. Reconstructive Review follows the <u>Creative Commons Attribution-NonCommercial</u> <u>CC BY-NC</u>. This license allows anyone to download works, build upon the material, and share them with others for non-commercial purposes as long as they credit the senior author, Reconstructive Review, and the Joint Implant Surgery & Research Foundation (JISRF). An example credit would be: "Courtesy of (senior author's name), Reconstructive Review, JISRF, Chagrin Falls, Ohio".

Sir HN Reliance Foundation Hospital, Prarthana Samaj, Girgaon-400004, Mumbai, Maharashtra, India

Introduction

The Extensor mechanism comprises of the quadriceps musculature, patella, patellar tendon and its attachment at the tibial tubercle. The disruption of the extensor mechanism can be a devastating complication post knee replacement surgery and its incidence has been reported to be between 0.17 to 2.5 % [1,2]. The cause of these ruptures can be multifactorial and can be primarily classified as patient related or the surgery related. An important part of management of these conditions is identifying the cause and if possible rectifying it along with the surgical repair or reconstruction.

Case Description

A 76 year old female presented in our OPD with Bilateral severe Osteoarthritis Knee. She had history of proximal femoral nailing done 3 years ago at some center for Intertrochanteric fracture in right hip, which failed eventually leading to pseudoarthrosis and a limb length discrepancy of 2.5cms with right lower limb being shorter than the left. The patient however was asymptomatic in right hip (Fig.1). Her pre-operative investigations were within normal limits except for low vitamin D3 level (10ng/ml) which was corrected with sup-



Figure 1. Pre-operative scanogram

plementation. Systemic disorders like Rheumatoid arthritis were ruled out pre-operatively. She underwent Simultaneous Bilateral total knee replacement by standard Medial parapatellar approach using Nexgen® LPS-Flex (Zimmer, Warsaw, USA). Patelloplasty was performed bilaterally and no lateral retinacular release was done. Good patellar tracking was seen using the no touch technique. Besides osteoporosis, mild fragility of the tissues was noted intraoperatively which were carefully dealt with.

The patient had a fall on hyperflexed knee on post-operative day 2, following which there was a superior pole pa-





Figure 2. Patella Fracture

Figure 3. TBW after Patella Fracture





Figure 4. Protruding K wires

Figure 5.R ight KneeP atella Alta

tella fracture (Fig.2), for which modified tension band wiring with two k wires was done (Fig.3). Adequate reduction of the fracture was obtained intra-operatively followed by a meticulous closure of the retinaculum and protection with above knee long extension brace postoperatively. After 6 weeks of index surgery, patient again had a twisting injury following which she presented with pain and instability following which she was completely bedridden. The examination of Left knee revealed anterior knee joint pain and swelling, positive straight leg raising test, an extension lag of 200 with further flexion upto 1000, palpable defect just above the superior pole of patella with the tips of the k wires being palpated subcutaneously. To our surprise, there was also Right knee anterior joint line tenderness with a positive straight leg raising test, extension lag of 200 with a further flexion of 1000 and a palpable defect below the patella. Bilateral knee joint x rays revealed a re-fracture with displacement of the k wires superiorly in the left knee joint (Fig.4) and patella alta in right knee (Fig.5). A diagnosis of bilateral knee extensor mechanism disruption was thus made and a decision to perform bilateral reconstruction at the same setting was taken.

Procedure: Under spinal anaesthesia in supine position, both the lower limbs were scrubbed and draped together.

Left Knee

In supine position, under tourniquet coverage, previous midline incision was used. After removal of the protruding K wires from the upper pole of patella, a complete tear of the quadriceps muscle associated with associated retinacular tear was identified (Fig.6). The femoral and tibial components and the poly insert were assessed carefully and found stable. An end to end Krackow type repair between the freshened quadriceps and the patella was executed with the help of polyester sutures (Ethibond Excel®, Johnson and Johnson, USA), which were passed through three vertical troughs in patella (Fig.7). Retinaculum was repaired and the reconstruction was assessed thoroughly. Knee was immobilized post-operatively with a cylindrical cast.





Figure 7. Repaired Quadriceps

Tendon Right arrow- Protriding

Figure 6. Left arrow- Quadriceps tear

Right Knee

In supine position, under tourniquet coverage, previous midline incision was used. Complete patellar tendon tear was identified at the level of inferior pole of patella. The semitendinosus tendon was isolated from the pes anserinus keeping the tendon insertion intact. An oblique tunnel was drilled just below the level of tibial tuberosity from inferomedial to supero-lateral direction. The prepared semitendinosus graft was first passed from the tibial tunnel followed by two vertical troughs, made in patella (Fig.8) and then finally sutured back at the level of pes anserinus insertion, holding the patella downwards (Fig.9). Retinaculum repair was done meticulously. The wound was closed over layers followed by immobilization with a cylindrical cast.

K wires

Mobilization was started on post-operative day 2 with the help of walker with full weight bearing as per pain tol-





Figure 8. Graft and Patella Trough

Figure 9. Hamstring Graft sutured



Figure 10. Follow-up at 1 year Lateral view

erance. Suture removal was performed after two weeks of surgery and the surgical wound was found healthy in both the knees.

Knee examination was performed after cast removal, 6 weeks after surgery which revealed No extension lag with an active flexion of around 300 in both the knees. Gradual active and assisted knee flexion was started as per the pain tolerance.

The Follow-up x rays of the patient after 1 year had good component positioning (Fig. 10) with No Extension Lag Clinically (Fig. 11 and Fig. 12)

Informed consent from the patient and her relatives was taken for reporting this case.

Discussion

Extensor mechanism injury after total knee arthroplasty, can be a disastrous complication, which can be dealt adequately by proper pre-operative planning and assessment. It is especially important to address the modifiable risk factors or any component malposition, before undertaking a







Figure 12. Follow-up at 1 year Right Leg





Figure 13. Scanogram Follow – up at 1 year

reconstruction in patients with extensor mechanism disruption following total knee replacement.

The Vascular supply of the extensor mechanism comes from intraosseous and extraosseous arterial ring (Fig.14). The extraossueous arterial ring is further divided in superior and inferior portions. The popliteal artery gives off four branches posteriorly, namely superior medial and lateral and inferior medial and lateral genicular arteries arising above and just below the knee joint line respectively. The supreme or the descending genicular artery arises from the femoral artery anteriorly just below the later enters the adduc-

tor hiatus. A Recurrent branch of the anterior tibial artery arises at the level of fibular neck just below the knee joint line. The intraosseous arterial ring further consists of mid patellar and infrapatellar osseous branches.

Standard Medial parapatellar approach being surgeon friendly, is one of the most commonly used approach for the knee arthroplasty with an advantage of wide exposure. However, as this approach involves splitting the quadriceps tendon proximally and medial retinaculum distally, it potentially compromises the medial blood supply of knee joint almost completely. It tends to disrupt the superior and inferior medial genicular and the superior genicular vessels. Furthermore, removal of the lateral meniscus and infrapatellar fat pad may lead to a compromise in the blood supply to patella by disrupting the lateral inferior genicular and the recurrent branch of anterior tibial artery.

The risk factors for the Extensor mechanism rupture have been summarized in Table 1.

The management of Extensor mechanism ruptures can

Table 1: Risk factors for Extensor Mechanism Rupture

Patient Factors	Surgery Factors	Implant Factors
Diabetes,	Stiffness & scarring	Overhang of tibial or
Rheumatoid	due to previous	patellar prosthesis,
Arthritis,	surgeries, proximal	Patellar over
Diabetes Mellitus,	tibial osteotomy,	resection, Patellar
Hypothyroidism,	prior infection,	underresection
Long Term steroids	anatomical	leading to over
intake, Chronic	variability like	stuffing of
Renal Failure	contracture of	patellofemoral
[3,4], Lupus	lateral retinaculum	joint, any prosthetic
erythematous, Intra-	requiring its release	malposition
articular Steriod	[5,6], Patella Baja	especially femoral
Injection, Obesity,	Osteonecrosis of	component in
Inflammatory Joint	Patella due to over	internal rotation
disease	resection patella	[5], medialization
	during resurfacing,	of the femoral or
	Patella Fracture [7],	tibial component
	Patella Eversion	and lateralization
	[8], Excision	of the patella
	of Infrapatellar	leading to increases
	fat pad [9], and	patellofemoral stress
	Patelloplasty	

be quite challenging and all aspects must be considered before embarking on surgical intervention. Of these, correcting the modifiable factors pre operatively is of utmost importance. The prognosis depends upon various factors - the duration since the tear occurred - Acute or chronic, the level of tear- Quadriceps tendon or retinaculum, patella fracture or patella tendon tear (intersubstance or tibial tuberosity avulsion), type of tear- Partial or complete and on the factors such as co-morbid conditions, condition of the tissues and bone and overall requirement and needs of the patient. Conservative treatment can be a good option in surgically unfit patients, patients refusing surgery, patients with patella fracture without loosening of the component and extensor lag of less than 200 in patients with partial tears [10]. The surgical intervention includes direct end to end repair using non absorbable sutures like polyethylene terephthalate like ethibond, staples [1], stainless steel circlage wires or suture anchors [11]. Augmentation can be beneficial in cases where the tendons and bones are fragile. Autologous augmentation grafts includes semitendinosus alone, semitendinosus along with gracilis graft [12,13], opposite side Bone patellar tendon bone graft [14], Turndown of the quadriceps tendon [15], ipsilateral medial gastrocnemius flaps [10]. The use of hamstring grafts like semitendinosus has been shown to have a stronger repair as compared to the free grafts for the reconstruction of extensor mechanism [12,16], The autologous grafts have an advantage of good tissue holding strength, is cost effective and is not associated with foreign body reaction like in case of allogenic grafts. The allogenic graft augmentation on the other hand is required in cases where more mechanical strength is required for the fixation to hold with poor quality of tissues as in cases of revision Knee arthroplasties. Allogenic graft options includes use of Achilles tendon graft [17], grafts comprising of quadriceps tendon, patella, patella tendon and tibial tubercle [18].

We used medial parapatellar approach with preservation of fat pad while performing bilateral knee replacements. No lateral release was done and also the patella was not replaced since the thickness of both the patella was <10mm. Investigating into the cause for these extensor disruptions, we identified few preoperative risk factors related to our case which were – history of inflammatory arthritis, low vitamin D3 levels (10ng/ml), a probable history of taking oral steroids (ayurvedic medicines) and a definitive history of intraarticular injections possibly steroids. Of the biomechanical cause: lack of a stable hip and frequent instability may have been a contributory factor. The component alignment was satisfactory on both sides with no overhangs or signs of component malrotation. While the Left side disruption occurred following a clear history of trauma, right side was a subtle injury highlighting the role of pre-existing factors predisposing to the same. This case is unique as to best of our knowledge only two studies have been published in literature mentioning about bilateral involvement of the extensor mechanism after total knee arthroplasty. One study mentions about bilateral simultaneous extensor mechanism rupture after simultaneous total knee replacement in a rheumatoid patient with chronic use of steroids [19]. The other study with bilateral extensor mechanism disruption was in two morbidly obese patients with previous total knee replacement done, among which one patient has a recurrent patellar tendon rupture [20].

We used end to end repair with krackow type sutures and patellar drill holes for quadriceps tendon rupture on one side and repair of patella tendon with augmentation by ipsilateral semitendinosus graft and both procedures gave a reasonably functional results at 1 year follow up. The augmentation was necessary to protect and add strength to the patellar tendon repair as the results of the end to end repair alone are very poor. Some studies have used a tension band wiring system as a protective measure for augmenting and protecting the repair but in our case we thought of using the natural hamstring tendon as the augmenting tissue. On the other side we were able to reattach the bulk of quadriceps tendon by making a trough into the superior pole of patella and protecting it with casting. Over the time the healing was reasonable good despite the concerns about the poor nature of the native tendon. The key to the procedure on this side was creating a healthy bone trough with bleeding bone that brings about the healing factors and optimizes the healing mechanism. Optimal protection of the repair is equally important to prevent failures.

In conclusion, we believe that this case report is unique for being a case of bilateral extensor mechanism disruption where in the disruptions occurred at different anatomical locations. It is important to screen the patients preoperatively, for any co-existing morbidities and risk factors and whenever possible optimize them before surgery. Augmented repairs for patellar tendon ruptures and primary repair of quadriceps tendon after creating a good boney trough on patella is a helpful technique for such disruptions.

Disclosure

The authors declare that there is no conflict of interest regarding the publication of this paper. For full disclosures refer to last page of this journal.

References

- Rand JA, Morrey BF, Bryan RS. Patellar tendon rupture after total knee arthroplasty. Clin Orthop 1989;224:233-8.
- Lynch AF, Rorabeck CH, Bourne RB, Extensor mechanism complications following total knee arthroplasty. J Arthroplasty. 1987; 2:135-40.
- Siwek CW, Rao JP, Ruptures of extensor mechanism of knee joint. J Bone Joint Surg Am. 1981;63:932-7.
- Rhoades DP, Noble PC, Reuben JD, et al. The effect of femoral component position on the patellar tracking after total knee arthroplasty. ClinOrthop. 1990; 260:43-51.
- McMahon MS, Scuderi GR, Glashow JL, et al: Scintigraphic determination of patellar viability after excision of infrapatellar fat pad and/or lateral retinacular release in total knee arthroplasty. Clin Orthop 260: 10-16, 1990.
- Scuderi G, Scharf SC, Meltzer LP, et al: The relationship of lateral release to patellar viability in total knee arthroplasty. J Arthroplasty 2: 209-214, 1987.
- Tria AJ, Harwood DA, Alicea JA, Cody RP. Patella Fractures in posterior stabilizer knee arthroplasties. Clin Orthop. 1194;299:131-138.
- Hempfing A, Schoeniger R, Koch PP, et al. Patellar Blood Flow during Knee Arthroplasty Surgical Exposure: Intraoperative Monitoring by Laser Doppler Flowmetry. Jr Orthop R. 2007;10.1002.
- Kayler D, Lyttle D. 1988. Surgical interruption of patellar blood supply by total knee arthroplasty. Clin Orthop 229:221–227.
- Rosenberg AG. Management of extensor mechanism rupture after TKA. J Bone Joint Surg Br. 2012;94-B:116-19.
- Kamath AF, Shah RP, et al. Suture anchor repair of patellar tendon rupture after total knee arthroplasty. J Knee surg. 2013; Dec;26(1):128-31.
- Cadambi A, Engh GA.Use of semitendinosus tendon autograft for rupture of the patellar ligament after total knee arthroplasty. A report of seven cases. J Bone Joint Surg Am. 1992 Aug;74(7):974-9.

- Maffulli N, Buono AD, et al. Ipsilateral Hamstring tendon graft reconstruction for chronic patellar tendon ruptures. J Bone Joint Surg Am. 2013;95:e123(1-6).
- Milankov MZ, Miljkovic N, Stankovic M. Reconstruction of chronic patellar tendon rupture with contralateral BTB autograft: A case report. Knee Surg Sports Traumatol Arthrosc. 2007 Dec;15(12):1445-8. Epub 2007 Jun 20.
- Scuderi C. Ruptures of the quadriceps tendon : study of twenty tendon ruptures. Am J Surg. 1958 Apr;95(4):626-34.
- Schoderbek RJ, Brown TE, Mulhall KJ, et al. Extensor mechanism disruption after total knee arthroplasty. ClinOrthop. 2006; 446:176-185.
- Crossett LS, Sinha RK, Sechriest VF, Rubash HE. Reconstruction of ruptured patellar tendon with Achilles tendon autograft following totak lnee arthroplasty. J Bone Joint Surg Am. 2008;84:1354-1361.
- Emerson RH Jr, Head WC, Malinin TI. Extensor mechanism reconstruction with an allograft after total knee arthroplasty. ClinOrthop 1994;303:79-85.
- Dussa CU, Singhal K. Bilateral simultaneous extensor mechanism disruption following simultaneous bilateral total knee replacement. Arch Orthop Trauma Surg. 2005; 125(6):396- 398.
- Goldstein ZH, Paul HY, Haughom BD, Hellman MD, et al. Bilateral Extensor Mechanism Disruption After Total Knee Arthroplasty in Two Morbidly Obese Patients Orthopaedics SLACK case report 2015 May;38(5):e443-6.

Make ICJR Your Source for Orthopaedic Education



Attend any one of our live events, including Global Congresses, CME Courses and Resident Training Programs.



Interact with experts and colleagues on hot topics in orthopaedics, benefit from enhanced access to on-line content, practice marketing support, and discounted text books.



Access a wealth of educational content anytime, anywhere from your computer or mobile device.



JOIN ICJR AND HELP SHAPE THIS GROWING GLOBAL COMMUNITY GIVING BACK TO ORTHOPAEDICS!





Reconstructive REVIEW



REVIEW

http://dx.doi.org/10.15438/rr.6.2.137

Total Hip Arthroplasty in Sickle Cell Disease

Manzary M¹

Abstract

Sickle cell disease (SCD) is a hemoglobinopathy characterized by abnormal morphology of blood cells causing transient interruption of blood supply to various body parts. Femoral Head avascular necrosis is one of the commonest skeletal sequeale of SCD.

Total Hip arthroplasty (THA) in SCD has evolved through different stages with a spectrum of results and technical challenges.

This article reviews the pathologic basis of sickle cell disease, the various challenges perioperatively associated with THA in SCD.

Keywords: Burch-Schneider cage, finite element analysis, Von Mises stresses, acetabular defect, bone support *Level of Evidence*: AAOS Therapeutic Level IV

Introduction

Sickle Cell Disease (SCD) is a genetic disease that is transmitted in an autosomal recessive mode characterized by substitution of Glutamic acid by Valine at the sixth position in the Beta peptide chain of the hemoglobin molecule. [2,3,5]

This results in the spatial configuration change of the helical hemoglobin structure in situation of decreased

oxygen, leading to change in the shape of red blood cells from the normal biconvex compressible shape to a sickle shaped one that is less deformable to be squeezed in, through the narrow diameter of the capillaries in various microcirculatory sites of the



Figure 1. Normal vs. Sickle Cell affected red blood cell.

human body. (Figure1)

The clinical sequelae of this hemoglobinopathy is predominantly the result of vasoocclusion and chronic hemolysis with resultant endothelial damage and ischaemic reperfusion injuries. [2,5,11]

The spectrum of clinical involvement includes skeletal and extra skeletal tissues of the body.

The skeletal manifestations of SCD may affect all age groups. Bony changes are due to hyperplasia of bone marrow and thrombosis that causes vascular infarction. Painful vasoocclusive crises is the most commonest skeletal man-

 Mojieb Manzary, MD Johns Hopkins Aramco Health Care Center, Dhahran, Saudi Arabia (Direct reprint requests to Mojieb Manzary)

Authors retain copyright and grant the journal right of first publication with the work. Reconstructive Review follows the <u>Creative Commons Attribution-NonCommercial</u> <u>CC BY-NC</u>. This license allows anyone to download works, build upon the material, and share them with others for non-commercial purposes as long as they credit the senior author, Reconstructive Review, and the Joint Implant Surgery & Research Foundation (JISRF). An example credit would be: "Courtesy of (senior author's name), Reconstructive Review, JISRF, Chagrin Falls, Ohio".

^{© 2016} Manzary. All rights reserved.

ifestation in SCD, a substantial majority of those may resolve over days without having any permanent sequelae.

Avascular necrosis of the femoral head is one of the common skeletal sequelae of SCD. This could be a bilateral involvement.

Avascular necrosis of bone, particularly of the femoral head, is challenging for patients and surgeons because it can produce significant pain and functional disability with no clearly proven ways of preventing progression of early stage disease. There are two popular classification systems for avascular necrosis (AVN) of the hip. These classifications are used for avascular necrosis from other causes (trauma, steroids, alcoholism) as well as for avascular necrosis from sickle disease. It is worth paying close attention to the etiology of avascular necrosis as well as the stage of disease because sickle cell AVN has a very poor prognosis compared with other causes, as further detailed below. In addition to the stage of collapse, the Steinberg classification 14 also includes quantification of the area of the femoral head involved by careful measurement of the plain x-rays.

The Ficat classification 6 was described in a paper published in 1985 which is among the classics in defining the pathoanatomy and pathophysiology of avascular necrosis. In this paper Ficat argued that avascular necrosis was analogous to a compartment syndrome of bone and could be treated in an analogous way by core decompression. The classification relies on functional testing of the bone with measurement of intraosseous pressure, venography, and core biopsy all of which are painful and invasive procedures no longer in widespread use. It is the clinical and plain x-ray aspects of the classification which have stood the test of time. Most textbooks, and therefore most trainees, discuss the Ficat system, but there are advantages to using the classification proposed by Steinberg.

Steinberg's classification is quite similar to that of Ficat for stages 0, 1 and 2 (early stage disease) with the main difference being that disease, not apparent on radiographs, is detected by either bone scan or MRI instead of functional testing of bone. While Ficat considered a crescent line to be 'between stages 2 and 3' (difficult!), Steinberg has divided late disease into finer stages with 3 being the crescent line and 4 through 6 progressive degenerative changes as outlined in the table. Importantly, for use in Africa, the Steinberg system relies only on careful evaluation of plain radiographs for all distinctions except that between stage 0 and stage 1.

There has been a medical revolution of treatment of SCD. Many sickle patients are treated with hydroxyurea, 3 a myelotoxic drug. The net effect of the marrow toxicity is to mildly suppress hematopoeisis and stimulate increased

production of fetal hemoglobin (Hb-F), which counteracts the tendency to sickle and reduces the manifestations and progression of the disease.

This treatment is supported by randomized controlled trial evidence (Level 1) from a US multicentre study led from Baltimore. [3]

Symptomatic avascular necrosis of the femoral head in adults has a very high probability of progression. Hernigou [7] reported on 92 symptomatic hips among 64 adult patients with sickle disease in a single centre prospective consecutive cohort study.

Seventy five hips had no radiographic collapse at presentation and all but ten of them had progressed to collapse within five years, with an average time to collapse of 42 months for stage 1 disease and 30 months for stage 2 disease. After 17 years of follow-up, 88 of the 92 hips had undergone some sort of operative procedure to treat intractable pain. In addition, the contralateral hip (if normal) showed plain X-ray changes of avascular necrosis among 20% of patients, and bilateral disease could be diagnosed in 23% of patients if symptoms or MRI findings were considered also. This prompted a study of the fate of the asymptomatic hip in patients with sickle disease.

The same author published a 2006 paper [8] following 121 initially asymptomatic contralateral hips in patients with sickle cell disease who were being seen for hip pain on the opposite side. Among these asymptomatic hips, 56 had normal plain x-rays and MRIs on presentation, 42 had abnormal MRI findings but normal plain films, and 23 had abnormal cystic or sclerotic appearance of the femoral head on plain films. The vast majority of asymptomatic hips became painful. Among those with abnormal plain x-rays at presentation 80% were painful by 2 years, among those with normal plain x-rays but abnormal MRIs 80% were painful by 3 years, and among those with normal plain xrays and normal MRIs 80% were painful by 16 years. Progression to collapse of the femoral head was seen in 100% of stage II hips within 5 years, 80% of stage I hips within 8 years, and 50% of otherwise apparently normal hips within 15 years - a dismal prognosis for an asymptomatic and apparently normal hip to say the least!

Compared with the poor prognosis for either symptomatic or asymptomatic contralateral hips in adults with sickle disease, children seem to fare a little better after osteonecrosis in sickle disease. Perhaps this is related to the remodeling potential of the growing skeleton. Again the study was reported by Hernigou [9] this time on 52 children with sickle related avascular necrosis from a mean age of onset of 12 years and with 19 years of follow-up. Only 1/3 of them had progressed to symptomatic osteoarthritis (stage IV disease or higher) and progression was more common among children with greater degrees of femoral head deformity from childhood, although some children with a completely round, nondeformed femoral head had progressed to osteoarthritis, strongly suggesting that biological factors play a significant role – for example there may be persistence of inflammatory pannus which eventually destroys even a mechanically perfect joint. Among the 31 patients, 2 had a second episode of avascular necrosis of the same hip during adulthood.

In summary, over 20% of adult sickle cell patients will develop avascular necrosis of the femoral head. Among those who do, progression to end stage hip disease is very common if they are followed for long enough. In addition, even an asymptomatic and radiographically normal contralateral hip has a high risk of progression to end stage arthritis as well.

The avascular necrosis will go through phases of healing and infarction ultimately leading to osteoarthritis which could be functionally disabling to the patient.Classically these patients are of relatively younger age, 2nd or 3rd decade of life, than the typical osteoarthritic patients in their 5th or sixth decade or even older.

Clinical Evaluation

Often, these patients are referred by hematologists or primary care physicians.It's very crucial to establish the exact symptoms for which the patients are suffering.It's

not uncommon that patients with SCD, although may have a positive imaging studies (X-ray or MRI) for Avascular necrosis, they may very well be having alternate etiologies for their symptoms.

We make it a point to see these patients few weeks (4-6 weeks), after the resolution of their acute attack of vasoocclusive crisis, in order for the acute pain to have subsided.At times acute or resolving synovitis from the acute painful crises might make the assessment of the hip osteoarthritic very challenging and confusing. We found that there are two common areas



Figure 2. Sacroiliac Joint Involvement in Sickle Cell Disease.

where the pain could be coming from apart from the affected hip.

The sacroiliac joint, (figure 2), is often involved to a various degree and serves as a cause of pain.Clinically it's confirmed by figure of 4 test, or by using a differential block injection for the SI joint.

Lower back pain , remains another differential for any hip pain.Proximal femoral metaphyseal infarct as a result of SCD may serve as a source of pain as well.

In cases where it's clinically too difficult to identify the source of pain, the affected hip could be injected by local anesthetic agent to rule it in out as a cause of pain.

Pre Operative Work Up

Once the diagnosis is confirmed and all nonoperative treatment modalities have failed, the discussion of total hip arthroplasty should be taken in great depth with the patient. It should be clearly highlighted to the younger SCD patients being considered for THA, that they will have to take risk of possibly having the THA revised once or more in their lifetime, in addition to the risk of infection and other technical issues of bleeding and possible fracture and perforation intraoperatively due to the deformity of their femora.If not seen by a hematologist, all sickle cell disease do have to be optimized by the hematologist.

In our institution, they get admitted a day prior to surgery to ensure that they're free from any infections mainly chest involvement and that they are hematological optimized.

We do not practice exchange transfusion. Our hematology colleagues believe in either pre op transfusion if needed, or intraoperative or postoperative transfusion, which will automatically dilute hemoglobin A levels. As in the literature we also recommend adequate hydration and use of perioperative antibiotics and analgesia.

Intraoperative Consideration

Most of patients with sickle cell disease are small built and short stature. Therefore we do ensure that our implant inventory contains smaller sizes femoral and acetabular components with respective heads and liners.

As these patients are predominantly young, we use cobalt chrome metal, or ceramic heads on highly cross linked polyethylene liner as our standard choice of implants.

Our standard implants choice are uncemented femoral and acetabular components in all of our primary total hip replacements, and we use the same for sickle cell disease patients as well, albeit with ensuring that smaller sizes are available. (Figure 3)



Figure 3. Sickle Cell affected hip joint, pre and post op x-rays using the regular implants.

In the usual cases of non-sickle patients we usually just rasp the femur prior to implanting the formal femoral component. But in patients with SCD we do consider reaming the femoral canals in to avoid any inadvertent deflection of the femoral component causing perforation. We always use a guide wire to check repeatedly the direction of our femoral canal reaming and rasping.

Furthermore, in some extreme cases of femoral canal narrowing due to neocortex formation in the endosteum, a DDH type of narrow straight cylindrical shape type of femoral stem may be required. (Figure 4)



Figure 4. Extremely narrow femoral canals in a patient with Sickle Cell Disease.

Judicious use of X-rays or image intensifier are encouraged in these cases to detect any unexpected perforation, fracture or malpositioning of the stem or the cup. Fracture of acetabulum or femur have been reported in patients with sickle cell disease.

Post Op Care

Our post op rehab protocol remains the same for patients with SCD and those who are not having SCD.The pain control post operatively might take longer to achieve it's goal in comparison to those who do not have SCD.

A major factor in this point is that these patients do already have been on chronic pain medications including narcotics, making their requirement for pain medications dosage to be higher and the rate of pain relief much limited.

The concern of implant survivorship in young patients does apply to these group of patients as well.

The type of fixation, cemented vs. cementless has been a topic of debate in the past, although recently cementless fixation are showing satisfactory results. A greater cause of concern in these patients is infection and subsequent loosening. A number of authors have cited various complications in THA in SCD patients. Al-Mousawi et al [2] reported 8 septic loosening in their series of 43 THA performed in 32patients.

They also reported perforation in seven acetabulum and four femurs. Aseptic loosening were reported in only one patients, wound hematoma in 5 patients. Acurio et al [1] reported 20% infection rate, 40% revision rates at a mean of 7.5 years in their 25 THA cases done for SCD.

The authors recommended to be cautious using methylmethacrylate as that could carry a higher risk for infection.

Their rate of revision was much higher in the cemented group 59% vs 22% in the cementless group.

Theoretically cement may provide an immediate rigid fixation and less intraoperative blood loss, decreased risk of femoral perforation, and minimizes the risk of possible suboptimal biologic fixation in a situation with compromised bone stock. The majority of contemporary reports of THA in SCD support the use of cementless femur and acetabulum fixation, with screws recommended as supplemental fixation in the acetabulum.

Elias & Moreau reported no evidence of femoral loosening in their 18 cementless hips done in patients with Sickle cell disease. [11]

Hanker & Amstutz [11] reported 50 % survivorship only by average of 5 years.Bishop et al, reported on 17 cases of cemented THA in SCD, 73% of patients were pain free at 8.9 yrs. [11]

Lachiewicz et al, reported on 16 cement less THA in 10

patients with good to excellent results in 87% of those cases using HHS scores. [11]

In our own audit on series of 12 cases of uncemented THA done in SCD vs. 22 cases of uncemented THA done in Non SCD patients, we found that the patients with SCD did significantly improve their pain and woman functions scores significantly from their pre op levels but were less than the scores of non SCD patients of similar age group matched on other key variables undergoing THA. (Figure 5)

Womac Scores



Womac Pain Womac Function Figure 5. Pre Op & Post Op Pain & Quality of life scores in patients with and without SCD undergoing THA.

We also have noticed that some of the SCD THA patients do not tolerate lengthening by more than 5-7 mm ,further than that they may start develop paresthesia and tingling.We apply the same revision THA protocol for work up & treatment of loosening of components in THA in SCD or non SCD patients. (Figure 6).



Figure 6. (A, B) Infected THA 10 years post op in a sickle cell disease pateint treated with 1st stage revision, (extraction with antibiotic spacer insertion).



Figure 7. (A, B) Post op xrays of infected THA treated with two stage reimplantation.

Few authors in the past used bipolar hemiarthroplasty in attempt to save the acetabulum young patient to a later time, however that practice has been abandoned and a number of those hemiarthroplasty hips have been revised to THA. (Figures 8,9)



Figure 8. Bipolar Hemiarthroplasty in patients with SCD done 12 years earlier.



Figure 9. Post op x-rays of the Bipolar hemiarthroplasty revised to THA.

Conclusion

THA in SCD patients presents both medical and surgical challenge. The increased likelihood of complications are due to the nature of sickle disease itself.Various preoperative and intraoperative issues needs to be taken into consideration, in regard of period optimization, type of implant, surgical techniques, method of fixation.

In spite of the variation in published compilations following THA in SCD, it still remains a very attractive procedure providing pain relief, function & satisfaction.in properly selected patients with SCD related AVN and or osteoarthritis.

Disclosure

The authors declare that there is no conflict of interest regarding the publication of this paper. For full disclosures refer to last page of this journal.

References:

- Acurio, M. T., & Friedman, R. J. (1992). Hip arthroplasty in patients with sicklecell haemoglobinopathy. J Bone Joint Surg Br, 74(3), 367-371. Retrieved from http://www.bij.boneandjoint.org.uk/content/74-B/3/367.full.pdf
- Al-Mousawi, F. (2004). Complications and failures of hip replacement in sickle cell disease. Bahrain Medical Bulletin, 26(4), 134-138.
- Charache S, Terrin ML, Moore RD, Dover GJ, Barton FB, Eckert SV, et al. Effect of hydroxyurea on the frequency of painful crises in sickle cell anemia. Investigators of the Multicenter Study of Hydroxyurea in Sickle Cell Anemia. N Engl J Med. 1995 May18;332(20):1317-22.

- Clarke, H. J., Jinnah, R. H., Brooker, A. F., & Michaelson, J. D. (1989). Total replacement of the hip for avascular necrosis in sickle cell disease. J Bone Joint Surg Br, 71, 465-470.
- Edington GM, Lehmann H. Expression of the sickle-cell gene in Africa. British medical journal. 1955 May 28;1(4925):1308-11
- Ficat RP. Idiopathic bone necrosis of the femoral head. Early diagnosis and treatment. J Bone Joint Surg Br. 1985 Jan;67(1):3-9.
- Hernigou, P., Bachir, D., & Galacteros, F. (2003). The natural history of symptomatic osteonecrosis in adults with sickle-cell disease. The Journal of bone and joint surgery. American volume, 85-A(3), 500-4. Retrieved from <u>http://www.ncbi.nlm.</u> <u>nih.gov/pubmed/12637438</u>
- Hernigou, P., Habibi, a, Bachir, D., & Galacteros, F. (2006). The natural history of asymptomatic osteonecrosis of the femoral head in adults with sickle cell disease. The Journal of bone and joint surgery. American volume, 88(12), 2565-2572.
- Hernigou P, Galacteros F, Bachir D, Goutallier D. Deformities of the hip in adults who have sickle-cell disease and had avascular necrosis in childhood. A natural history of fifty-two patients. J Bone Joint Surg Am. 1991 Jan;73(1):81-92.
- Hernigou, P., Zilber, S., Filippini, P., Mathieu, G., Poignard, A., & Galacteros, F. (2008). Total THA in adult osteonecrosis related to sickle cell disease. Clinical Orthopaedics and Related Research (Vol. 466, pp. 300-308).
- Jeong, G. K., Ruchelsman, D. E., Jazrawi, L. M., & Jaffe, W. L. (2005). Total hip arthroplasty in sickle cell hemoglobinopathies. The Journal of the American Academy of Orthopaedic Surgeons, 13(3), 208-17. Retrieved from <u>http://www.ncbi.</u> <u>nlm.nih.gov/pubmed/15938609</u>
- Perfetti, D. C., Boylan, M. R., Naziri, Q., Khanuja, H. S., & Urban, W. P. (2015). Does sickle cell disease increase risk of adverse outcomes following total hip and knee arthroplasty? A nationwide database study. J Arthroplasty, 30(4), 547-551. Retrieved from <u>http://www.arthroplastyjournal.org/article/S0883-5403(14)00824-</u> 9/abstract.
- Powars DR, Chan LS, Hiti A, Ramicone E, Johnson C. Outcome of sickle cell anemia: a 4-decade observational study of 1056 patients. Medicine (Baltimore). 2005 Nov;84(6):363-76.
- Steinberg ME, Hayken GD, Steinberg DR. A quantitative system for staging avascular necrosis. J Bone Joint Surg Br. 1995 Jan;77(1):34-41
- Stuart MJ, Nagel RL. Sickle-cell disease. Lancet. 2004 Oct 9-15;364 (9442):1343-60.

COURSE CHAIRMAN



RICHARD J. FRIEDMAN, ME FRCSC Medical University of South Carolina Charleston, SC

COURSE CO-DIRECTORS



RAFFY MIRZAYAN, MD Kaiser Permanente Los Angeles, CA



JOHN W. SPERLING, MD, MBA Mayo Clinic Rochester, MN



JOSEPH D. ZUCKERMAN, MD New York University Hospital for Joint Diseases New York, NY "THIS IS A FANTASTIC COURSE! INTIMATE SETTING/TOP NOTCH PRESENTATION/CORRECT DEPTH OF SUBJECT COVERAGE" -2015 MEETING ATTENDEE

5TH ANNUAL SHOULDER COURSE SPORTS MEDICINE | TRAUMA | ARTHROPLASTY LAS VEGAS, NV | NOVEMBER 3-5, 2016

www.icjr.net/2016shoulder

MARK A. FRANKLE, MD

EDWARD G. MCEARLAND, MD

JOINTLY PROVIDED BY:



MICHAEL D. MCKEE, MD, FRCSC MARK A. MIGHELL, MD TOM R. NORRIS, MD KEVIN D. PLANCHER, MD MATTHEW L. RAMSEY, MD TIMOTHY G. REISH, MD ROBIN R. RICHARDS. MD. FRCSC

Howard D. Routman, do Felix H. Savoie, III, MD Paul M. Sethi, MD Thomas W. Quin Throckmorton, Me Stephen C. Weber, MD Ken Yamaguchi, MD, MBA

ICJR

FEATURING

ADVANCED CONCEPTS®

IN SPORTS

MEDICINE

Joint Implant Surgery & Research Foundation • JISRF.org • ReconstructiveReview.org

JOSEPH A. ABBOUD, MD

EMILIE CHEUNG, MD FRANCES CUOMO, MD THOMAS R. DUQUIN, MD

JAMES C. ESCH, MD



Reconstructive REVIEW



ORIGINAL ARTICLE

http://dx.doi.org/10.15438/rr.6.2.139

SuperPATH[®] Minimally Invasive Total Hip Arthroplasty - An Australian Experience

Qurashi S¹, Chinnappa J¹, Rositano P¹, Asha S²

Abstract

Introduction: SuperPATH[®] is a new minimally invasive technique for hip replacement surgery that was introduced in Australia in 2013. The aim of this study was to assess short-term patient outcomes and surgical results of SuperPATH hip replacements in Australia.

Methods: A retrospective cohort analysis of the first 100 SuperPATH hip replacements by a single surgeon was performed. Surgical outcomes were reviewed with a minimum follow-up of 1 year post operation. A functional and patient satisfaction questionnaire was administered at a minimum of 6 weeks post operation.

Results: There were 3 major complications with 1 revision operation in this series. There were no dislocations. By 2 weeks post operation, 86% of patients were ambulant without walking aids, 84% of patients were able to dress themselves independently and 91% of patients did not need opioid analgesia. 81% of patients were driving within 4 weeks of surgery. Of patients who were working full-time prior to surgery, 33% of them were back at work or functional baseline within 1 week post surgery, and 52% by 2 weeks. 100% of patients were extremely satisfied with the operation.

Conclusion: We conclude that SuperPATH is a safe technique of hip arthroplasty with excellent functional recovery and patient satisfaction.

Keywords: arthroplasty, replacement, hip; minimally invasive surgical procedures; patient outcome assessment; learning curve; complications

Level of Evidence: AAOS Therapeutic Level IV

Introduction

Total Hip Arthroplasty (THA) has been a successful operation for treatment of end-stage degenerative disease of the hip. [1] Although excellent results are usually obtained in terms of mobility and analgesic effects, patients often have to modify their activity to accommodate hip dislocation precautions for variable time durations according to individual rehabilitation protocols. This can involve several weeks of avoiding driving [2], time off work and modi-

- Dr. Suleman Qurashi, MBBS, FRACS (Ortho), Dr. Jason Chinnappa, MBBS, MS (Ortho), Dr. Pasquale Rositano, MBBS Department of Orthopaedic Surgery, The Canterbury Hospital, Canterbury, NSW, Australia (Direct reprint requests to Suleman Qurashi)
- 2 Dr. Stephen Asha, MBBS, FACEM Department of Emergency Medicine, St. George Hospital, Kogarah, NSW, Australia

© 2016 Qurashi, Chinnappa, Rositano, Asha. All rights reserved. Authors retain copyright and grant the journal right of first publication with the work. Reconstructive Review follows the <u>Creative Commons Attribution-NonCommercial</u> <u>CC BY-NC</u>. This license allows anyone to download works, build upon the material, and share them with others for non-commercial purposes as long as they credit the senior author, Reconstructive Review, and the Joint Implant Surgery & Research Foundation (JISRF). An example credit would be: "Courtesy of (senior author's name), Reconstructive Review, JISRF, Chagrin Falls, Ohio".

fication of daily activities. [3,4]

With today's patients living longer and leading more active lifestyles, newer minimally invasive, muscle sparing operative techniques are being pursued. This aims to take advantage of progressive technology and allow better short-term results, early return to function and avoidance of conventional hip precautions. One such technique garnering increased focus is the Supercapsular Percutaneously Assisted Total Hip (SuperPATH[®]) Arthroplasty which has yielded excellent technical results by the pioneer of the technique in the United States. [5]

The aim of this study was to measure surgical and functional outcomes in the short term of a single surgeon series using the SuperPATH technique in Australian Practice.

Method

The first 100 patients (including initial learning-curve) who underwent total hip arthroplasty using the SuperPATH technique [5] by a single surgeon, were interviewed at six weeks post operation. The surgeries were performed between June 2013 and February 2015 across six different hospitals. Un-cemented prostheses (MicroPort Orthopedics Inc., Arlington, TN, USA; Dynasty Acetabular component, Profemur L Classic monoblock femoral component) were used with metal on polyethylene or ceramic on polyethylene bearing surfaces. All patients were treated with the same operative technique, perioperative care and rehabilitation protocol. Interviews were conducted over the phone by the same interviewer.

Patient Selection

All patients who underwent THA using the SuperPATH

technique were included in the analysis. Patients who had their surgery with the traditional posterior approach were excluded from the study. Patients whose operations began as a minimally invasive technique but had to be converted into the traditional posterior approach intra-operatively for any reason were excluded from the functional outcome study but not from reporting of complications. No patients were excluded from the operative technique and the study on

Figure 1. A: Interval between gluteus minimus and piriformis (tagged with suture) B: Capsulotomy with anterior capsular leaf lifted by Cobb elevator (right) and piriformis (left) tagged with suture. C: Femoral broach in canal with neck in-situ

the basis of their age, Body Mass Index (BMI), hip pathology or medical comorbidities.

Operative Technique

Standard anterior-posterior pelvic and lateral hip hard copy radiographs obtained pre-operatively were used to template for sizing implants. After induction of general anaesthesia an indwelling urinary catheter was inserted. The patients were positioned lateral decubitus and secured on a pegboard with radiolucent pegs. A mayo stand was utilised to rest the patients' foot and facilitate manoeuvring of the hip (similar to positioning for a traditional posterior approach). Intravenous antibiotic therapy thirty minutes prior to, and tranexamic acid infusion (15mg/kg) at time of, skin incision were routinely used. Patients received two further doses of intravenous antibiotics and tranexamic acid at eight and 16 hours post surgery.

The operative procedure was based on the recommended SuperPATH technique. [6] A skin incision was made proximal to the greater trochanter in line with the medullary axis of the femoral shaft. Electrocautery dissection was then performed through subcutaneous tissue and gluteus maximus fascia with no extension of dissection into the ilio-tibial band. Finger dissection of the gluteus maximus fibres was followed by retraction of the underlying gluteus medius and minimus through the interval between these muscles (Figure 1). The piriformis tendon was tagged at this stage but not routinely released, while none of the other short external rotator tendons were released. Retractors were placed between the piriformis tendon posteriorly and gluteus minimus anteriorly to expose the capsule. The capsule was tagged and incised in line with the skin incision. The piriformis fossa was then visualised and femoral preparation commenced.

The femoral canal was reamed and broached to a stable fitting trial stem, with the femoral neck left intact and head in-situ during this process (Figure 1). The in-situ broach was then used as an intramedullary guide to neck osteotomy, followed by extraction of the femoral head using Schanz pins in a piecemeal fashion. An acetabular guide (similar to a trial cup) was then inserted to allow a guided stab incision and passage of blunt trocar and cannula posterior to the femoral shaft. This allowed access of instrumentation for acetabular preparation. Following line to line reaming of the acetabulum under direct vision, the definitive acetabular component and liner were inserted. Adjunct acetabular screws were used as a routine practice despite rim capture. Trial femoral components were then reduced and tested for stability and tissue tension. Once satisfied, the definitive head and femoral stem were inserted. Local anaesthetic infiltrate with ropivacaine 1% was administered to the soft tissues surrounding the exposure and hip joint. After closure of the capsule and gluteus maximus fascia, the skin was closed with a running absorbable suture. Steristrips and a waterproof dressing were applied, and a mobile AP radiograph of the pelvis obtained in recovery.

Post-operative rehabilitation

Patients were given either oral analgesia (regular paracetamol and meloxicam with as required oxycodone), or patient controlled analgesia (intravenous morphine or fentanyl) for the first 18 hours post operation, after which time all patients were put on the aforementioned oral analgesic regime. Patients on chronic pain medication were continued on their regular medications in addition to the oral analgesics mentioned above.

Patients were mobilised 15-20 metres around the ward by the physiotherapists post operation on the day of surgery. All patients were encouraged to mobilise independently when confident and comfortable, and no hip precautions were recommended post surgery. Patients were discharged from hospital once cleared from a mobility point of view by the physiotherapist. Most patients received outpatient physiotherapy with a focus on muscle strengthening and mobility (including deep squats and crossing legs to reach shoes, socks and toenails). No patients were referred to inpatient rehabilitation from a mobility point of view. Patients were encouraged to speak to their insurers and employers and were not given specific instructions regarding fitness to work or drive.

Follow-up

All patients were followed up at two weeks and six weeks post operation with repeat radiographs. Patients

were then followed up with repeat radiographs at 6 months, 18 months and 2 yearly check ups thereafter. No patients were lost to follow-up.

Functional and Patient Satisfaction questionnaire

Patients were contacted by phone at six weeks post surgery and asked about the time-frame post surgery to achieving independent aid-free mobility, cessation of narcotic analgesia, return to work or day to day function and return to driving. These questions comprised on the functional component of the Harris Hip Scores [7] and were based on a similar study investigating functional recovery following a direct anterior approach. [8] Patients were also asked about their satisfaction with the procedure by means of their opinion on the surgery using a Likert scale (Excellent, Very Good, Good, Fair, Poor) and their likelihood in choosing this method of surgery again (Yes, No, Maybe).

Ethics Approval

Ethics approval for this study was obtained from the Hunter New England Ethics Committee (Reference 15/03/18/5.01).

Statistical Analysis

Normally distributed data are presented as means with standard deviations (SD) and 95% confidence intervals, while non-normally distributed data is presented as medians with inter-quartile ranges (IQR). Categorical data is presented as proportions.

Results

A total of 100 SuperPATH technique patients were included in this study with minimum follow-up of 1 year post-operation. Four patients were excluded from this study after beginning as SuperPATH approaches but being converted intra-operatively to traditional posterior approaches (three due to difficult exposure, one to assess suspected peri-prosthetic calcar fracture). 23 patients were excluded having undergone a planned traditional posterior approach due to equipment unavailability (n=11) or lack of consent (n = 12; nine booked on waitlist prior to surgeon commencing SuperPATH, three waitlist reduction patients of other surgeons). Included patient pre-operative baseline characteristics are provided in Table 1.

There were a total of four surgical complications and one medical complication within the included series of patients, with one patient requiring revision arthroplasty surgery. There was one surgical complication in the excluded patient group. One patient sustained an undisplaced peri-prosthetic fracture (Vancouver B2) with stem subsidence at eight to ten weeks post surgery. This occurred after a twisting injury whilst coming down stairs. The patient was treated conservatively protected weight bearing for four weeks. The same patient sustained a Vancouver C peri-prosthetic frac-

Characteristics	Mean	(SD)	Range
Age (years)	64	(11)	25 - 88
	Median		Range
BMI	28.0		20- 41
ASA	2		1-3
	n	(%)	
Sex			
Male	60	(60)	
Female	40	(40)	
Side of operation			
Left	44	(44)	
Right	56	(56)	
Pre-operative Hip Pathology			
Osteoarthritis	92	(92)	
Avascular necrosis	5	(5)	
Post-septic arthritis	1	(1)	
Ankylosing Spondylitis	1	(1)	
DDH [†]	1	(1)	

Table	1.	Raseline	natient	charact	toristics	(n - 100)
Tuble	1.	Daseine	paiieni	cnaraci	ensucs	(n=100)

[†]Developmental Dysplasia of the Hip

ture after being hit by a motor vehicle twelve weeks post surgery. He was treated with surgical fixation by a plate construct, which later failed due to non-union and plate breakage. This was subsequently revised with a long stem revision implant with the primary stem noted to be well in-

grown intra-operatively. At time of writing, there have been no other re-operations needed for any reason.

There were two incidences of early implant migration. One patient had subsidence of the femoral component after falling at home two weeks post surgery. She was placed partial weight-bearing for four weeks and gradually allowed to increase weight-bearing after progress imaging showed stable component position. A second patient was found to have acetabular component loss of position during routine imaging at the two-week post-operative review. As she was asymptomatic and clinically stable, she was placed partial weight-bearing for four weeks, and then allowed to fully weight-bear after repeat radiographs showed stable component position. Both patients remained asymptomatic at one year follow-up.

Other surgical complications in the SuperPATH[®] patient group were one psoas tendon avulsion post surgery treated conservatively and one instance of symptomatic leg length discrepancy (LLD; 1.5cm long on the operative side) treated with a contralateral 0.8cm heel-raise. One patient had a myocardial infarct day one post-operation and recovered well with medical therapy. Of the four excluded (converted to posterior approach) patients, there was one complication with a symptomatic leg length discrepancy of 1.5cm. There were no neurovascular injuries, dislocations, infections (superficial or deep), venous thrombo-embolic events or intra-operative peri-prosthetic fractures in any of the patients.

A fellowship trained musculoskeletal specialist radiologist independently reviewed all THA postoperative radiographs and reported all acetabular prostheses to be well seated and anteverted. The inclination of the acetabular components had a mean of 34.4 (SD 7.38) degrees with a range of 15 to 56 degrees.

Overall median hospital length of stay post surgery in this series was 3 days. Median hospital LOS post surgery was 2 days at public hospitals (mean 2.3, range 1-10, SD 1.89) and 4 days at private hospitals (mean 3.7, range 1-10, SD 1.92). No patients needed to attend inpatient rehabilitation to achieve their mobility goals prior to discharge. No patients in the public system attended inpatient rehabilitation. Some patients in the private system had pre-booked inpatient rehabilitation (patient's discretion) via their insurance and proceeded to attend this despite achieving physiotherapy discharge goals.

Functional questionnaire cumulative percentage results are provided in Figure 2. One patient used walking aids for non-arthritis related reasons, 55 patients were retired



Figure 2. Cumulative percentage of participants who regained function or ceased using opiate analgesics over time

or did not work and 10 patients did not drive and so their responses were excluded from the relevant sections of the functional questionnaire analysis.

100% of patients were extremely satisfied with the SuperPATH operative experience, with a summary of their opinions on this method of surgery provided in Table 2.

Table 2: Patient Satisfaction

	n	(%)	95% CI
Patient opinion of operation			
Excellent	90	(90)	83 – 95
Very good	10	(10)	5 – 17
Good	0	(0)	-
Fair	0	(0)	-
Poor	0	(0)	-
Would the patient have the operation again?			
Yes	99	(99)	97 – 100
Maybe	1	(1)	0-3
No	0	(0)	-

Discussion

A variety of minimally invasive and muscle-sparing approaches to THA have been gaining interest amongst patients and orthopaedic surgeons. Studies have shown both successes [8] and complications [9] of other muscle sparing techniques . SuperPATH offers the comfort of ability to easily extend the approach into a traditional posterior approach to the hip when required. The effectiveness of the SuperPATH approach has been demonstrated overseas by its pioneer. [5] SuperPATH has also been shown to be costeffective when compared with the lateral approach. [10] The purpose of this study was to describe the initial clinical results of this method in Australian practice, it's reproducibility as a safe and reliable technique, as well as its effectiveness regarding patients' functional outcomes. With no patients lost to follow-up, we feel this study is an accurate reflection on initial SuperPATH THA outcomes.

We feel this exposure is applicable to all primary elective hip replacement situations, although there were not many patients with DDH or inflammatory arthritis in this series and further cases may be needed to support this. Similarly, none of the cases were performed in the trauma setting and conclusions regarding SuperPATH THA for intracapsular neck of femur fractures cannot be made. The cases were spread out across different hospital with different assistants and nursing staff at each site without any identifiable difference in surgical outcomes. Furthermore no patients were excluded from this technique on the basis of their medical comorbidities, BMI or hip pathology. The four cases excluded due to conversion to traditional posterior approach all had BMI less than 25 and primary osteoarthritic hips. These patients were also spread out throughout the case series, without any identifiable learning curve correlation.

Complication rates were minimal in this series of the first 100 patients performed using the SuperPATH technique. Our finding of all post-operative radiographs showing appropriately positioned prosthetic components is similar to another study concerning SuperPATH THA in North America. [11] There were no dislocations in this series, even with no patient having to comply with any post-operative restrictions immediately post surgery. This included most patients performing movements such as deep squats and crossing legs to get to shoes, socks and toenails in the early post operative period. No approaches have reported a zero percent dislocation rate [12–14] and dislocation was the second most common reason for revision surgery in the Australian Joint Replacement Registry. [15] The LLD rate in this series is lower than other reported incidences of LLD following THA [16,17] whilst there were no known intra-operative fractures, venous thromboembolic events or infections in this series.

Of the two early implant migrations, the femoral one occurred following a fall. Whilst no clear cause of the acetabular loss of position was identified, this may have been a result of an unidentified (not seen on high resolution artefact reduced computed tomography scan) intra-operative acetabular fracture. Both these cases have responded well to conservative treatment. Only one patient in this series required re-operation and revision arthroplasty surgery that was related to a traumatic periprosthetic fracture. Additionally, the complications in this series were evenly distributed and not biased towards the beginning or "learning curve".

The high rate of patients achieving early independent mobility, independent dressing including shoes and socks, and cessation of narcotics in our study lends credence to the benefit of the soft tissue preservation aspect of Super-PATH. Most patients were independent with their mobility the day after surgery. Although social circumstances often contributed to increased LOS, a few specific factors may be responsible for the variation in the median length of stay between public and private hospital patients. Some patients had pre-booked rehabilitation beds, whilst some private insurance company's different rates of remuneration / case payment conditions linked based on minimum LOS may also have contributed. A large portion of patients in our study felt comfortable and confident driving within a month of surgery. No instructions were given to patients beyond checking with their insurer and being off narcotics before driving. Although no legal guidelines dictate not driving period post THA [18–20], current recommendations [21] suggest no driving for a minimum of six weeks post THA. These are based on literature for traditional THA approaches. [2] Due to the nature of SuperPATH, we feel these recommendations may not be applicable as a result of the different degree of soft tissue trauma and altered musculoskeletal mechanics involved. Study into driving after SuperPATH THA is required to further investigate this area.

Patients who were not retired or unemployed were asked about duration of time post surgery to return to work. As many of them had pre-booked 6 weeks of sick leave and did not want to return to work prior, they were also alternatively asked about time to reach their baseline day to day function. With over 50% of patients returning to work/ function within two weeks of surgery, SuperPATH offers an excellent option for motivated patients to minimise time off work after their joint replacements. Our study is limited in that actual work duties were not detailed so no specific recommendations can be made to patients beyond being guided by their comfort and employer.

Patients in this study were also extremely satisfied with the SuperPATH operative experience. The only non-positive feedback was one patient (1%) who was undecided on whether they would choose this method of operation again, although they did still rate the operative experience overall as "Very Good".

Limitations of this study include recall bias due to the retrospective nature of the patients' questionnaires, and the absence of validated functional hip scores. As most of the patients had not completed pre-operative functional hip score questionnaires, there was no baseline comparison to interpret post-operative scores. A final limitation of this study is that longest patient follow-up in this series is two and a half years to date and long-term survivorship and patient outcomes (although these may not be influenced by surgical technique) cannot be concluded at this stage. However, the short-term results to date suggest a promising future for SuperPATH THA in Australia.

Conclusion

The results of this study show that SuperPATH is a reproducible technique of performing THA with minimal complications, quick functional recovery and excellent patient satisfaction.

Disclosure

The authors declare that there is no conflict of interest regarding the publication of this paper. For full disclosures refer to last page of this journal.

References:

- Learmonth ID, Young C, Rorabeck C. The operation of the century: total hip replacement. Lancet. 2007 Oct 27;370(9597):1508–19.
- Marecek GS, Schafer MF. Driving after orthopaedic surgery. J Am Acad Orthop Surg. 2013 Nov;21(11):696–706.
- Cowie JG, Turnbull GS, Turnball GS, Ker AM, Breusch SJ. Return to work and sports after total hip replacement. Arch Orthop Trauma Surg. 2013 May;133(5):695–700.
- Sankar A, Davis AM, Palaganas MP, Beaton DE, Badley EM, Gignac MA. Return to work and workplace activity limitations following total hip or knee replacement. Osteoarthr Cartil. 2013 Oct;21(10):1485–93.
- Chow J, Penenberg B, Murphy S. Modified micro-superior percutaneously-assisted total hip: early experiences & case reports. Curr Rev Musculoskelet Med. 2011 Sep;4(3):146–50.
- About SuperPath® Hip Replacement | SuperPath® Hip Replacement [Internet]. [cited 2015 May 17]. Available from: <u>http://www.superpathhiptechnique.com/physicians/about-superpath.asp</u>
- Harris WH. Traumatic Arthritis of the Hip after Dislocation and Acetabular Fractures: Treatment by Mold Arthroplasty. J Bone Joint Surg Am. 1969 Jun 1;51(4):737–55.
- Berger RA, Jacobs JJ, Meneghini RM, Della Valle C, Paprosky W, Rosenberg AG. Rapid Rehabilitation and Recovery with Minimally Invasive Total Hip Arthroplasty: Clinical Orthopaedics and Related Research. 2004 Dec;429:239–47.
- Hallert O, Li Y, Brismar H, Lindgren U. The direct anterior approach: initial experience of a minimally invasive technique for total hip arthroplasty. J Orthop Surg Res. 2012;7:17.
- Gofton W, Fitch DA. In-hospital cost comparison between the standard lateral and supercapsular percutaneously-assisted total hip surgical techniques for total hip replacement. Int Orthop. 2015 Jul 9;
- Della Torre PK, Fitch DA, Chow JC. Supercapsular percutaneously-assisted total hip arthroplasty: radiographic outcomes and surgical technique. Ann Transl Med. 2015 Aug;3(13):180.
- Masonis JL, Bourne RB. Surgical approach, abductor function, and total hip arthroplasty dislocation. Clin Orthop Relat Res. 2002 Dec;(405):46–53.
- Sariali E, Leonard P, Mamoudy P. Dislocation after total hip arthroplasty using Hueter anterior approach. J Arthroplasty. 2008 Feb;23(2):266–72.
- Soong M, Rubash HE, Macaulay W. Dislocation after total hip arthroplasty. J Am Acad Orthop Surg. 2004 Oct;12(5):314–21.
- Australian Orthopaedic Association National Joint Replacement Registry. Adelaide: AOA; 2014.
- García-Juárez JD, Bravo-Bernabé PA, García-Hernández A, Jiménez-Cabuto CI, García-Rosas MS. [Incidence and effect of leg length discrepancy after total hip arthroplasty]. Acta Ortop Mex. 2013 Feb;27(1):43–6.
- Wylde V, Whitehouse SL, Taylor AH, Pattison GT, Bannister GC, Blom AW. Prevalence and functional impact of patient-perceived leg length discrepancy after hip replacement. Int Orthop. 2009 Aug;33(4):905–9.
- -MacLeod K, Lingham A, Chatha H, Lewis J, Parkes A, Grange S, et al. "When can I return to driving?": a review of the current literature on returning to driving after lower limb injury or arthroplasty. Bone Joint J. 2013 Mar;95-B(3):290–4.
- Assessing Fitness to Drive Austroads [Internet]. [cited 2015 Sep 10]. Available from: <u>http://www.austroads.com.au/drivers-vehicles/assessing-fitness-to-drive</u>
- Nuñez VA, Giddins GEB. "Doctor, when can I drive?": an update on the medico-legal aspects of driving following an injury or operation. Injury. 2004 Sep;35(9):888–90.
- Arthroplasty Society of Australia- Position Statement on Driving after Total Hip and Knee Replacement Surgery [Internet]. [cited 2015 Jun 16]. Available from: <u>https://www.aoa.org.au/docs/default-source/subspecialties/arthposdrive.</u> <u>pdf?sfvrsn=2</u>

"Almost" is Not Clean Enough.



Almost Clean: Tibia After Pulsatile Saline Lavage

CarboJet[®]

Fully Clean: Same Tibia After CarboJet

CO₂ Bone Preparation System



Discover why so many surgeons are making CarboJet a standard part of their cement bed preparation technique. The CarboJet's CO, gas jet quickly and thoroughly cleans and dries the bone surface by bringing blood, saline and, most importantly, fatty marrow elements to the surface where they are easily collected and removed. Cleaning and drying with CarboJet takes less time than is typically required for drying with lap sponges.

In clinical use since 1993, CarboJet has been shown to be safe and effective in multiple clinical studies and in tens of thousands of joint reconstructive procedures. Nozzles are available for use in TKA, UKA, THA, TSA and other cemented applications. Give it a try and see what a really clean bone bed is all about!

Clinically Proven

Increased Cement Penetration: Goldstein (2007) Improvement of cement mantle thickness with pressurized carbon dioxide lavage. ISTA, Paris, France,

Increased Bone-Cement Interface Strength: Stanley (2010) Bone-Cement interface strength in distal radii using two medullary canal preparation techniques. Hand Surg 15:95.

Reduced Opportunity for Micro-Emboli: Lassiter (2010) Intraoperative embolic events during TKA with use of pulsatile saline versus carbon dioxide lavage. ORS. New Orleans, USA.

Facilitates Tourniquet-free TKA: Jones (2011) Total Knee Arthroplasty without the use of a tourniquet. Seminars in Arthroplasty 22:176. CE



For additional information or to schedule a product evaluation, please give us a call at 800-827-5775. To view a video demonstration, visit us on the Web at: www.kinamed.com

CarboJet® U.S. Patent No. 8,100,851; 8,712,595. Additional US & International Patents Pending. ©2015 Kinamed® Inc. B00140F JBJS

Got Radiolucent Lines?

Bone bed prepared with pulsatile saline lavage. Arrows indicate radiolucent lines.



Bone bed prepared with CarboJet. No radiolucent lines visible.



NAMED[®] INCORPORATED

Expect Innovation.



"THIS COURSE COVERS ONE OF THE MOST EXCITING AND INNOVATIVE ADVANCES IN ORTHOPEDICS WITH SIGNIFICANT PATIENT BENEFITS." -2015 MEETING ATTENDEE

5TH ANNUAL DIRECT ANTERIOR APPROACH HIP COURSE

JW MARRIOTT I HOUSTON, TX SEPTEMBER 22-24, 2016

www.icjr.net/2016anterior

COURSE CHAIRMEN





JOHN L. MASONIS, MD



MICHAEL NOGLER, MD University of Innsbruck Innsbruck, Austria

JISRF Mission Statement

he specific and primary endeavors are to operate for scientific purposes by conducting medical research of potential improvements in medical surgical methods and materials for preserving and restoring the functions of the human body joints and associated structures which are threatened or impaired by defects, lesions or diseases.



This Journal as all activities conducted by JISRF are available to all interested surgeons, scientists and educators. Our focus is on new cutting edge technologies, science – all with the intent to raise the level of discussion and discovery. Please become a part of this endeavor, we look forward to your interest and participation.



esign

Develop

rototype

Manufacture

Signature Orthopaedics is a design, development and manufacturing company for orthopaedic implants and instruments.

The head office located in Sydney Australia, with offices in Europe and North America.

We have years of experience in taking concepts right through design and development and into certification, whether it be the FDA, BSI or the TGA.

We are routinely supplying parts for the Hip, Knee, foot and ankle, spine, shoulder, both to the locally and international markets. With the added capability of making custom implants for specific cases, using the latest software to guarantee the perfect fit.

We are happy to design and develop both instruments and prosthesis for your needs, or we can supply one of our many FDA approved solutions as an OEM vendor. Our product, your box!









all or email to discuss which solution is right for you!

Signature Orthopaedics Europe 88 Harcourt St Dublin Ireland T+353 1 691 5293F+353 1 691 5010 Signature Orthopaedics Australia 7 Sirius Rd Lane Cove West NSW Australia T+61 2 9428 5181 F+61 2 8456 6065 info@signatureortho.com.au www.signatureortho.com.au Signature Orthopaedics USA Sunset Road Las Vegas NV United States T+1 702 750 2600

GLOBAL | PERSONAL | PORTABLE







MEMBERSHIP

Join us and gain access to a wealth of educational resources on icjr.net, including:

- Online CME
- Extensive library of surgical videos performed by leading orthopaedic surgeons
- Live, real-time broadcasts of ICJR meetings from around the world as well as archived video content
- News and updates on cutting edge procedures and technologies
- Articles featuring the latest orthopaedic information
- Exclusive content from Rothman Institute and NYU Langone
- ICJR Mobile App

Benefits of a Sustaining Membership

- Benefit from unlimited access to premium content created just for ICJR
- Discount on meeting registration fees
- Earn CMEs online at a discounted fee
- Help support resident & fellow education



APPLY FOR MEMBERSHIP AT www.icir.net



DOWNLOAD THE ICJR MOBILE APP FOR FREE AT WWW.icjr.net/app



MAKE ICJR YOUR SOURCE FOR ORTHOPAEDIC EDUCATION

ICJR LIVE MEETINGS AROUND THE GLOBE

*MEMBERS RECEIVE A \$100 DISCOUNT OFF REGISTRATION FEES!

MEETING	DATES	LOCATION	COURSE CHAIRS & DIRECTORS
4th Annual Revision Hip & Knee Course*	May 6 – 7	Philadelphia, PA	Charles L. Nelson, MD Craig L. Israelite, MD Gwo-Chin Lee, MD
4th Annual South/RLO Spring Hip & Knee Course*	May 19 – 21	Charleston, SC	Walter B. Beaver Jr. MD H. Del Schutte Jr., MD
ICJR Instructional Course at the 9th Congress of the Chinese Association of Orthopaedic Surgeons	May 20	Chengdu, China	Henry D. Clarke, MD Richard Kastenbaum, MD Yan Wang, MD,
3rd Annual Pan Pacific Orthopaedic Congress*	August 10 – 13	Big Island, HI	Matthew S. Austin, MD Kazuo Hirakawa, MD, PhD Richard D. Komistek, MD Rajesh N. Maniar, MS, MCh Raj K. SInha, MD, PhD
5th Annual Direct Anterior Approach Hip Course*	August 11 – 14	Houston, TX	Stefan W. Kreuzer, MD Joseph T. Moskal, MD, FACS John L. Masonis, MD Michael Nogler, MD
3rd Annual Transatlantic Orthopaedic Congress (17th Annual ISK Sports Medicine & Total Hip & Knee Course in collaboration wth EKS)*	October 7 – 9	New York, NY	Jean-Noël A. Argenson, MD, PhD W. Norman Scott, MD, FACS William J. Long, MD, FRCSC Richard Iorio, MD Emmanuel Thienpont, MD
24th Annual Perspectives in Joint Arthroplasty: Updates in Knee Replacement	October 21 - 22	Fall River, KS	J. Christopher Banwart, MD Kenneth A. Greene, MD
ICJR Russia	October	St. Petersburg, Russia	Siegfried Hofmann, MD Rashid Tikhilov, MD
ICJR/KOA Instructional Course	October	Seoul, Korea	Henry D. Clarke, MD Dae Bae, MD
5th Annual Shoulder Course*	November 3 – 5	Las Vegas, NV	Richard J. Friedman, MD, FRCSC John W. Sperling, MD, MBA Joseph D. Zuckerman, MD
ICJR Middle East	November 3 – 5	Dubai, UAE	Samih Tarabichi, MD
ICJR Instructional Course at the 11th International Congress of the COA	November	Beijing, China	TBD
9th Annual Winter Hip & Knee Course*	January 12-15, 2017	Vail, CO	Raymond H. Kim, MD Fred D. Cushner, MD Mark W. Pagnano, MD

GO TO WWW.icjr.netifor detailed information about upcoming meetings.



Play a Role in Our Ground Breaking Research



erhaps you were a patient and you were able to regain an important part of your life. Or, perhaps you are simply someone interested in medical research and seeking a new way to participate. Whatever the case, your generosity in helping to fund research is critical to our success - and much appreciated.

The Joint Implant Surgery & Research Foundation is a not-for-profit 501(c)(3) corporation. Your contributions enable scientific discoveries that will help future patients. Contributions over the years from people like you have helped to shape orthopaedics today.

Contributions

Donations of any amount will immediately be put to use to fund ongoing and future orthopaedic research projects.

How to Give

- Your gift of cash, securities or other negotiable assets is immediately put to use in our research.
- Your contributions are fully tax deductible as specified under Section 501(c)(3) regulations.

For more information please visit our website at www.jisrf.org or contact us at:

Joint Implant Surgery & Research Foundation 46 Chagrin Shopping Plaza, #117 Chagrin Falls, OH 44022 440.785.9154

BRENNAN, MANNA & DIAMOND



is known nationally for its experience and expertise in Healthcare & Hospital Law.

From physicians to hospital medical staff, from home healthcare providers to allied health professionals and everything in between, BMD can develop and implement strategic plans specifically designed to help you meet and navigate the ever changing healthcare environment.

We serve as legal counsel <u>AND</u> as business and strategic advisors to our healthcare clients.

We give our clients peace of mind so they can get back to the business of caring for their patients.

For more information contact our Health Law Department 75 E. Market Street, Akron, OH 44308 • (330) 253-5060 • www.bmdllc.com



Joint Implant Surgery & Research Foundation • JISRF.org • ReconstructiveReview.org



International Congress for Joint Reconstruction

REGISTER NOW!

Global

3rd Annual PAN PACIFIC ORTHOPAEDIC CONGRESS

Hilton Waikoloa | Big Island of Hawaii | August 10-13, 2016

CO-CHAIRMAN

Matthew S. Austin, MD Philadelphia, PA, USA

Kazuo Hirakawa, MD, PhD Kamakura, Japan **Richard D. Komistek, PhD** Knoxville, TN, USA

Rajesh N. Maniar, MD Mumbai, India

Raj K. Sinha, MD, PhD LaQuinta, CA, USA

HIGHLIGHTS

- Multiple opportunities to interact with a faculty of 30 orthopaedic experts from around the world
- See the future of orthopaedics through the eyes of leading industry CEOs
- Lively debates, case presentations, surgical vignettes and quick-fire panels
- Get tips from world renowned orthopaedic surgeons on strategies for enhanced recovery

www.icjr.net/2016panpacific



GLOBAL PERSONAL PORTABLE MAKE ICJR YOUR SOURCE FOR ORTHOPAEDIC EDUCATION AT WWW.ICJR.NET

Levels of Evidence

Reconstructive Review has adopted the American Academy of Orthopaedic Surgeons (AAOS) Levels of Evidence for Primary Research Question. These guidelines will now be part of the review process for manuscript submission.

Levels of Evidence For Primary Research Question¹

	Types of Studies			
	Therapeutic Studies – Investigating the results of treatment	Prognostic Studies – Investigating the effect of a patient characteristic on the outcome of disease	Diagnostic Studies – Investigating a diagnostic test	Economic and Decision Analyses – Developing an economic or decision model
Level I	 High quality randomized trial with statistically significant difference or no statistically significant difference but narrow confidence intervals Systematic Review² of Level I RCTs (and study results were homogenous³) 	 High quality prospective study⁴ (all patients were enrolled at the same point in their disease with ≥ 80% follow- up of enrolled patients) Systematic review² of Level I studies 	 Testing of previously developed diagnostic criteria on consecutive patients (with universally applied reference "gold" standard) Systematic review² of Level I studies 	 Sensible costs and alternatives; values obtained from many studies; with multiway sensitivity analyses Systematic review² of Level I studies
Level II	 Lesser quality RCT (e.g. < 80% follow- up, no blinding, or improper randomization) Prospective⁴ comparative study⁵ Systematic review² of Level II studies or Level 1 studies with inconsistent results 	 Retrospective⁶ study Untreated controls from an RCT Lesser quality prospective study (e.g. patients enrolled at different points in their disease or <80% follow-up.) Systematic review² of Level II studies 	 Development of diagnostic criteria on consecutive patients (with universally applied reference "gold" standard) Systematic review² of Level II studies 	 Sensible costs and alternatives; values obtained from limited studies; with multiway sensitivity analyses Systematic review² of Level II studies
Level III	 Case control study⁷ Retrospective⁶ comparative study⁵ Systematic review² of Level III studies 	• Case control study ⁷	 Study of non- consecutive patients; without consistently applied reference "gold" standard Systematic review² of Level III studies 	 Analyses based on limited alternatives and costs; and poor estimates Systematic review² of Level III studies
Level IV	Case Series ⁸	Case series	 Case-control study Poor reference standard 	• Analyses with no sensitivity analyses
Level V	Expert Opinion	Expert Opinion	Expert Opinion	Expert Opinion

1. A complete assessment of quality of individual studies requires critical appraisal of all aspects of the study design.

- 2. A combination of results from two or more prior studies.
- 3. Studies provided consistent results.
- 4. Study was started before the first patient enrolled.
- 5. Patients treated one way (e.g. cemented hip arthroplasty) compared with a group of patients treated in another way (e.g. uncemented hip arthroplasty) at the same institution.
- 6. The study was started after the first patient enrolled.
- 7. Patients identified for the study based on their outcome, called "cases"; e.g. failed total arthroplasty, are compared to those who did not have outcome, called "controls"; e.g. successful total hip arthroplasty.
- 8. Patients treated one way with no comparison group of patients treated in another way.

JISRF Founder



Charles Bechtol, MD

was internationally known in the fields of biomechanics and orthopedic surgery. His engineering and biomechanical research resulted in the development of numerous joint replacement implants and internal fracture fixation devices – instruments that are familiar to orthopedic surgeons the world over. His innovations included shoulder and knee prostheses, the Bechtol Total Hip system, the Bechtol "fluted" bone screw, and the Bechtol "continuous strength" bone plate.

Visit www.jisrf.org for more information.



1971 by Prof. Charles O. Bechtol, MD.

) JISRF

Reconstructive Review Disclosure Statement

The following information will be published on each paper.

Please check one or more if pertinent of the following:

- \Box 1. No benefits or funds were received in support of this article.
- \Box 2. Benefits or funds were received in support of this article either directly or indirectly.
- □ 3. Either family, institution I am associated with, or I have received benefits or funds either directly or indirectly regarding this article.
- \Box 4. Describe:

Author's Signature:

(Typed signature is valid for online submission.)

Joint Implant Surgery & Research Foundation

www.jisrf.org

Conflict of Interest Statement JISRF Orthopaedic Industry Affiliations (Past & Present)

Many Authors, Co-Authors, JISRF, or its Members have had affiliations past or present with one or more of these organizations.

AAHKS AAOS American Society of Biomechanics Apex Surgical Australian Orthopaedic Association Bactrin International, INC. Concept Design & Development, DePuy Dow Coring Wright Encore Medical E.M. Warburg, Pincus & Co., LLC Global Orthopaedic Technology Harrington Arthritis Research Center Howmedica ISTA Johnson & Johnson Joint Medical Products Corp. Kirschner Kenesis Medical, Inc Montreal General Hospital Orthopaedic Lab NASA ORS OrthoDevelopment OTI Richards Manufacturing Signature Orthopaedics Smith & Nephew, Inc. Society for Biomaterials Zimmer

Disclosure Statement

JISRF and the Reconstructive Review take disclosure very serious and often readers don't appreciate the indirect benefit writers receive in publications. Many of our contributors are officially associated with JISRF by the membership on study groups, editorial committee and or clinical / surgical advisors. JISRF is dependent on donations and commercial funding. The overall success of this funding benefits indirectly all that are associated with activities produced by JISRF.

Disclosure for Authors

Article 1, page 13. Buntting [1]; Sorial [1]; Coffey [1]; Eslick [1]

Article 2, page 21. Rastogi [1]; Marya [1]

Article 3, page 31. Sharma [1]; Bagaria [1]; Nadange [1]; Waghchoure [1]; Shah [1]; Tangirala [1]; Wadia [1]

Article 4, page 37. Manzary [1]

Article 5, page 43. Qurashi [1]; Chinnappa [1]; Rositano [1]; Asha [1]



World Class Healthcare, Orthopaedics "Sports Medicine," Rehabilitation, Plastic Surgery, Research & Education



Future Site Selected For This Cutting-Edge Medical Initiative



S ince 1948, the Greenbrier Clinic has been recognized as an industry leader in executive health and wellness through utilizing advanced diagnostics in the early diagnosis, prevention and treatment of disease. Building upon that history of medical excellence, Jim Justice, Chairman and owner of the Greenbrier Resort, has announced the

creation of the Greenbrier Medical Institute. The institute's 1st phase is projected to cost about \$250 million, employ more than 500 people and include 3 buildings.

This phase will include an expansion of our world renowned executive health and wellness practice, The Greenbrier Clinic, which will be bolstered by a world-class sports medicine

program, including an orthopedic surgery center and athletic performance/rehabilitation facility, all led by the Founder of the American Sports Medicine Institute, Dr. Jim Andrews and Chair of Cleveland Clinic Innovations, Thomas Graham. Rounding out the Institute's services will be a firstin-class plastic and cosmetic surgery and Lifestyle Enhancement Academy, helping people look and feel their best. Physicians, universities, research foundations, medical journals and other healthcare industry leaders, all of whom are on the cutting edge of medical technology, research and care, have committed to join the project and establish

> an international research and education destination or "think tank" to stimulate research, drive innovation, force change and redefine how the world approaches health, wellness and longevity.

The Institute's facility, designed by Willie Stokes, will feature Georgian architecture similar to the resort's façade, a replica of the Springhouse, the site of the

famous sulphur springs and special guests suites for patients and their families. Jack Diamond, President and CEO, and Mark Krohn, COO, are leading the development of this exciting project and are actively looking for other physicians and medical thought leaders to be involved.

For more information, please contact:

Mark E. Krohn, Chief Operating Officer Greenbrier Medical Institute, 330-697-6581 mekrohn@bmdllc.com





Joint Implant Surgery and Research Foundation 46 Chagrin Shopping Plaza, #117 Chagrin Falls, Ohio 44022 www.jisrf.org