

# J B & J S

## THE JOURNAL OF BONE & JOINT SURGERY

PUBLISHED IN TWO VOLUMES

### AMERICAN VOLUME

CEO/Publisher: KENT R. ANDERSON

Editor-in-Chief: VERNON T. TOLO

Editors Emeriti: JAMES D. HECKMAN,  
HENRY R. COWELL

Deputy Editors Emeriti for Research: ALBERT H. BURSTEIN,  
LAWRENCE C. ROSENBERG

#### EDITORIAL BOARD

THOMAS W. BAUER, *Deputy Editor for Research*  
THOMAS D. BROWN, *Deputy Editor for Research*  
ROBERT W. BUCHOLZ, *Deputy Editor for Adult Reconstruction & Trauma*  
CHARLES R. CLARK, *Deputy Editor for Adult Reconstruction and Spine*  
THOMAS A. EINHORN, *Deputy Editor for Current Concepts Reviews*  
BRENT GRAHAM, *Deputy Editor for Methodology and Biostatistics*  
ANDREW GREEN, *Deputy Editor for the Upper Extremity*  
JAMES D. HECKMAN, *Deputy Editor for Foot and Ankle*  
ALAN S. HILIBRAND, *Deputy Editor for AOA Publications*

MICHELLE A. JAMES, *Deputy Editor for the Upper Extremity*  
JEFFREY N. KATZ, *Deputy Editor for Methodology and Biostatistics*  
ELENA LOSINA, *Deputy Editor for Methodology and Biostatistics*  
MARK D. MILLER, *Deputy Editor for Sports Medicine*  
DEMPSEY S. SPRINGFIELD, *Deputy Editor for Instructional Course Lectures*  
MARC F. SWIONTKOWSKI, *Deputy Editor for Outcome Studies and Trauma*  
JAMES G. WRIGHT, *Associate Editor for Evidence-Based Orthopaedics*  
RICK W. WRIGHT, *Associate Editor for Evidence-Based Orthopaedics*  
JAMES D. CAPOZZI, *Coordinator of Ethics in Practice*

STEPHEN A. ALBANESE, Syracuse, New York  
JEAN-NOEL A. ARGENSON, Marseille, France  
LEON S. BENSON, Glenview, Illinois  
EDWARD Y. CHENG, Minneapolis, Minnesota  
JOHN CLOHISEY, St. Louis, Missouri  
LARS ENGBRETSEN, Oslo, Norway  
MARYBETH EZAKI, Dallas, Texas  
CHRISTIAN GERBER, Zurich, Switzerland  
MARK R. HUTCHINSON, Chicago, Illinois  
NORMAN JOHANSON, Philadelphia, Pennsylvania  
ENG LEE, Singapore  
SETH S. LEOPOLD, Seattle, Washington  
KONSTANTINOS N. MALIZOS, Larissa, Greece  
DAISUKE TOGAWA, Hakodate City, Hokkaido, Japan

#### THE JOURNAL OF BONE AND JOINT SURGERY INCORPORATED

Board of Trustees

EDWARD N. HANLEY Jr., *Chairman*  
STUART L. WEINSTEIN, *Vice-Chairman*  
RICHARD H. GELBERMAN, *Treasurer*  
PETER STERN, *Secretary*  
JAMES H. HERNDON  
JAMES H. BEATY  
TERRY LIGHT  
ANDREW WEILAND

#### THE AMERICAN ORTHOPAEDIC ASSOCIATION

*President: DOUGLAS R. DIRSCHL*

#### THE AMERICAN ACADEMY OF ORTHOPAEDIC SURGEONS

*President: DANIEL J. BERRY*

#### BOARD OF CONSULTING EDITORS FOR RESEARCH

H. CLARKE ANDERSON, Kansas City, Kansas  
STEVEN ARNO CZKY, East Lansing, Michigan  
SCOTT BODEN, Atlanta, Georgia  
JOSEPH A. BUCKWALTER, Iowa City, Iowa  
CHARLES CORNELL, New York, N.Y.  
KATHLEEN DERWIN, Cleveland, Ohio  
MICHAEL KLEIN, Birmingham, Alabama  
KEITH MARKOLF, Los Angeles, California  
EDWARD McCARTHY Jr., Baltimore, Maryland  
HARRY A. McKELLOP, Los Angeles, California  
JAVAD PARVIZI, Philadelphia, Pennsylvania  
TERRANCE D. PEABODY, Chicago, Illinois  
SCOTT A. RODEO, New York, N.Y.

#### WESTERN ORTHOPAEDIC ASSOCIATION

*President: THEODORE L. STRINGER*

#### EASTERN ORTHOPAEDIC ASSOCIATION

*President: JOHN C. RICHMOND*

#### MID-AMERICA ORTHOPAEDIC ASSOCIATION

*President: GORDON R. BELL*

### BRITISH VOLUME

Editor: JAMES SCOTT

Editor Emeritus: FRANK HORAN

#### BRITISH EDITORIAL BOARD

LESLIE KLENERMAN, *Associate Editor Emeritus*  
MICHAEL LAURENCE, *Associate Editor Emeritus*  
JOSEPH DIAS, *President, B.O.A., ex officio*  
MATT COSTA, *Editorial Secretary, B.O.A.*  
ROGER M. ATKINS, Bristol, England  
PAUL BEAULÉ, Ottawa, Canada  
GEORGE BENTLEY, London, England (EFORT)  
MARTIN BIRCHER, London, England  
TIMOTHY BRIGGS, London, England  
JAMES CALDER, London, England  
MICHAEL DUNBAR, Halifax, Canada  
RICHIE (H.S.) GILL, Oxford, England (B.O.R.S.)  
S. GOVENDER, Congella, South Africa  
FARES HADDAD, London, England

#### NEW ZEALAND ORTHOPAEDIC ASSOCIATION

GARY HOOPER, *President*  
P.O. Box 7451, Wellington South, New Zealand

#### SOUTH AFRICAN ORTHOPAEDIC ASSOCIATION

THEO LE ROUX, *President*  
GERT J. VLOK, *Hon. Secretary*  
P.O. Box 12918, Brandhof 9324, South Africa

#### IRISH ORTHOPAEDIC ASSOCIATION

WILLIAM QUINLAN, *President*  
7 Seabury Court, Malahide, Co. Dublin

#### EUROPEAN FEDERATION OF NATIONAL ASSOCIATIONS OF ORTHOPAEDICS AND TRAUMATOLOGY - EFORT

MIKLOS SZENDROI, *President*  
Technoparkstrasse 1, CH-8005 Zürich, Switzerland

ALEXANDER HADJIPAVLOU, Crete, Greece  
ROBERT HAWKINS, Vancouver, Canada  
PIERRE HOFFMEYER, Geneva, Switzerland  
GREGORY JAMES, Perth, Australia  
ROGER LEMAIRE, Liège, Belgium  
DAVID MORGAN, Brisbane, Australia  
SUSAN STOTT, Auckland, New Zealand  
NICO VERDONSCHOT, Nijmegen, The Netherlands  
TIM WILTON, Derbyshire, England

#### BRITISH ORTHOPAEDIC RESEARCH SOCIETY

ALLEN GOODSHIP, *President*  
IAN McNAMARA, *Secretary*  
Division of Orthopaedic and Accident Surgery, C Floor West Block  
Queen's Medical Centre, Nottingham NG7 2UH

#### EUROPEAN ORTHOPAEDIC RESEARCH SOCIETY

ENRIQUE GÓMEZ-BARRERA, *President*  
EDWARD R. VALSTAR, *Secretary*  
Vienna Academy of Postgraduate Medical Education and Research  
Alser Strasse 4, 1090 Vienna, Austria

#### CANADIAN ORTHOPAEDIC RESEARCH SOCIETY

CARI M. WHYNE, *President*  
STEVEN BOYD, *Secretary*  
4150 Ste. Catherine Street West  
Suite 360, Westmount, Quebec H3Z 2Y5

#### British Office

22 Buckingham Street, London WC2N 6ET, England  
*Managing Director:* PETER RICHARDSON  
*Head of Editorial Publishing Services:* EMMA VODDEN  
*Head of Subscriptions and Customer Service:* MICHAEL SEARLE  
*Head of Marketing and Sales:* LUCY STEPHENSON  
*Head of Administration and HR:* TESSA CLARKE

Published in the United Kingdom by  
The British Editorial Society of Bone & Joint Surgery

# JB&JS

## THE JOURNAL OF BONE & JOINT SURGERY

### AMERICAN OFFICE

20 Pickering Street, Needham, Massachusetts 02492-3157 U.S.A.

CEO/PUBLISHER: KENT R. ANDERSON

EDITOR-IN-CHIEF: VERNON T. TOLO

ASSOCIATE PUBLISHER/GENERAL MANAGER: MADY TISSENBAUM

MANAGING EDITOR: AMY BORDIUK

*Published and printed in the United States by The Journal of Bone and Joint Surgery, Incorporated*

### INFORMATION FOR SUBSCRIBERS

SUBSCRIPTION MANAGER, Abraham N. Brody  
ASSISTANT SUBSCRIPTION MANAGER, Merle Adelson

To start or stop a subscription, to change your address, or for non-receipt of issues:

subs@jbjs.org

781.433.1241 Fax: 781.449.9742

JBJS-A is a benefit of AAOS Active Fellowship.

### 2012 SUBSCRIPTION RATES—Individuals only

PRINT + ONLINE

\$182.00 in USA

\$199.00 outside USA

Published twice monthly.

Resident/fellow discount rates and complimentary subscriptions are available; contact subs@jbjs.org for details.

SUBSPECIALTY CORRIDORS (electronic)

\$49.00 each, with a subscription to JBJS

Available for the following subspecialty areas:

Elbow	Pediatrics
Foot & Ankle	Shoulder
Hand & Wrist	Spine
Hip	Sports Medicine
Knee	Trauma
Oncology	

Subscription rates above apply to individuals only.

For institution subscription information and rates, please contact the Subscription Department at subs@jbjs.org.

### ONLINE ACCESS INFORMATION

Online access to the full text plus additional features is included in all subscription prices. Visit us at [www.jbjs.org](http://www.jbjs.org) to learn more.

### INFORMATION FOR AUTHORS

For questions concerning submission of manuscripts or status of submitted manuscripts:

editorial@jbjs.org

781.433.1210 Fax: 781.449.9787

MANAGING EDITOR, Amy Bordiuk

EDITORIAL MANAGER, Allan Harper

For questions regarding manuscript style and format:

dsibor@jbjs.org 781.433.1243

### ADVERTISING

DIRECTOR, Amber Howard

ahoward@jbjs.org 781.433.1233

PRINT AND DIGITAL PRODUCTION MANAGER, Beverly Ouannass

bouannass@jbjs.org 781.433.1234

INSTITUTION AND RECRUITMENT ADVERTISING SALES MANAGER,

Terry Paolino

tpaolino@jbjs.org 781.433.1239

NATIONAL ADVERTISING REPRESENTATIVE, Tim Reimer

treimer@jbjs.org 781.433.1229

Advertising Department Fax: 781.449.3485

MIDWEST ADVERTISING REPRESENTATIVES,

Jeffrey Dembski, Steve Loerch

jdembski@jbjs.org or sloerch@jbjs.org

847.498.4520 Fax: 847.498.5911

PHARMACEUTICAL ADVERTISING REPRESENTATIVE,

James T. Brady, Inc.

jtbrady1@verizon.net

516.742.7960 Fax: 516.742.7908

### JBJS CHANGE OF ADDRESS FORM (NOTIFY US 60 DAYS IN ADVANCE OF CHANGE)

Old Address (Fill in Old Address Here)	New Address (Fill in New Address Here)
Name _____	Name _____
Address _____	Address _____
_____	_____
City _____ State _____ Postal/Zip Code _____	City _____ State _____ Postal/Zip Code _____
e-mail address _____	e-mail address _____

### How to Reach Us

Editorial and business offices: 20 Pickering Street, Needham, Massachusetts 02492-3157. Telephone: 781.449.9780  
www.jbjs.org · mail@jbjs.org · Editorial Fax: 781.449.9787 · Advertising Fax: 781.449.3485 · Subscription Fax: 781.449.9742