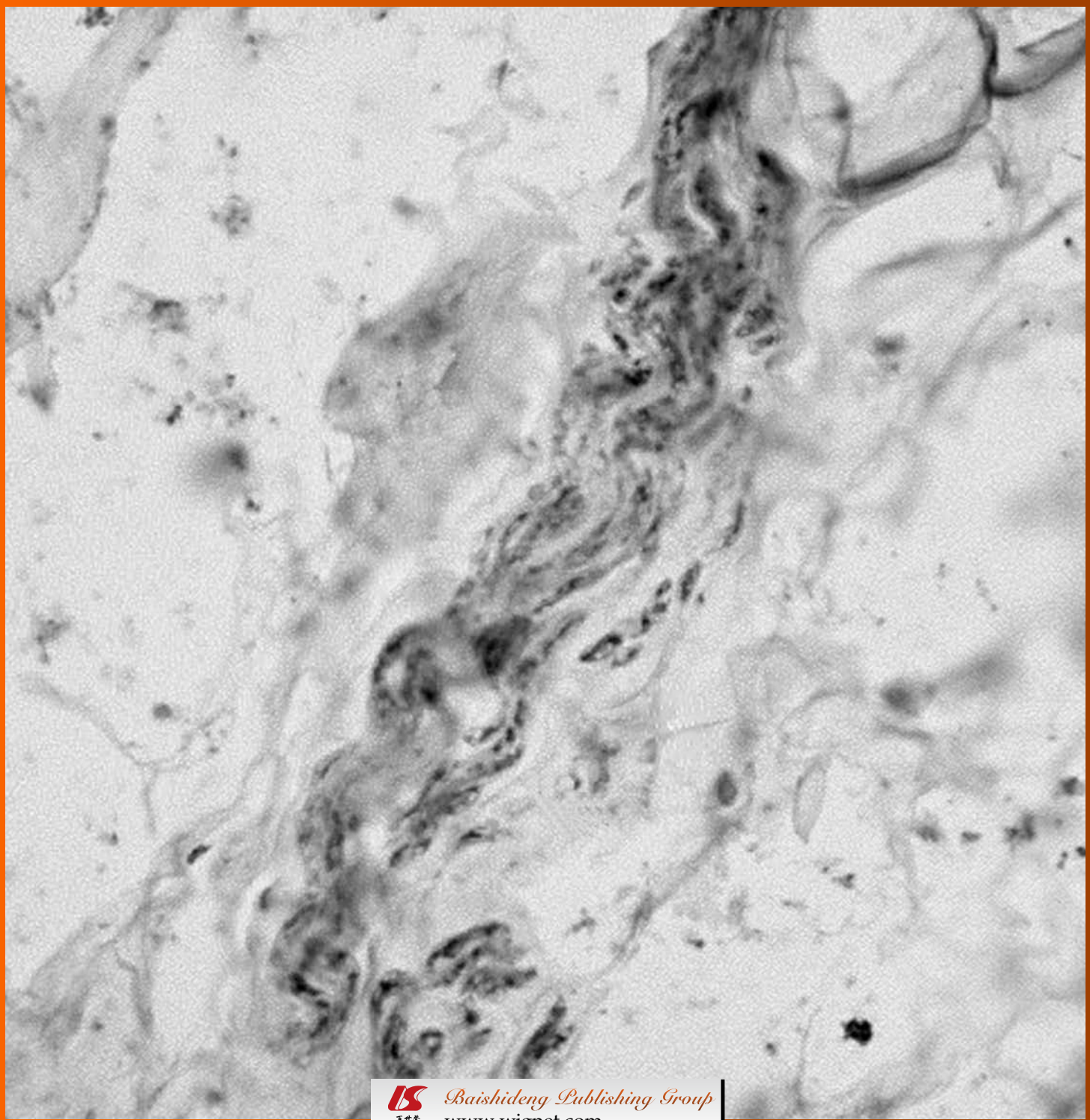
ISSN 2218-5836 (online)

World Journal of *Orthopedics*

World J Orthop 2012 February 18; 3(2): 10-19



Baishideng Publishing Group
www.wjgnet.com

WJO World Journal of Orthopedics

A peer-reviewed, online, open-access journal of orthopedics

Editorial Board

2010-2014

The *World Journal of Orthopedics* Editorial Board consists of 261 members, representing a team of worldwide experts in orthopedics. They are from 30 countries, including Argentina (1), Australia (14), Austria (2), Belgium (1), Brazil (3), Canada (5), China (18), Croatia(2), Denmark (1), Egypt (2), Finland (2), France(2), Germany (10), Greece (5), Hungary (1), India (9), Iran (2), Ireland (1), Israel (5), Italy (19), Japan (14), Morocco (1), Netherlands (10), Norway (2), Portugal (1), Serbia (3), Singapore (3), South Korea (12), Spain (4), Sri Lanka (1), Sweden (3), Switzerland (6), Tunisia (3), Turkey (1), Tunisia (1), United Kingdom (6), and United States (69).

Yrjö T Konttinen, *Helsinki*

France

Federico Canavese, *Clermont-Ferrand*
Yiou Eric, *Orsay Cedex*

Germany

Annegret Mündermann, *Radolfzell*
Beat Knechtle, *Gallen*
Heinz LOHRER, *Frankfurt Am Main*
Olaf Lorbach, *Homburg*
Stefan Grote, *Munich*
Karsten Knobloch, *Hannover*
Philipp Kobbe, *Aachen*
Volker Schöffl, *Bamberg*
Arndt P Schulz, *Lübeck*
Lars V Baron von Engelhardt, *Bochum*

Greece

George C Babis, *Attiki*
Marios Georgios Lykissas, *Ioannina*
Lazaros I Sakkas, *Larissa*
Nikolaos G Papadimitriou, *Thessaloniki*
Konstantinos N Malizos, *Larissa*

Hungary

Andor Sebestyén, *Pécs*

India

Antony Gomes, *Calcutta*
Kunal Sharan, *Lucknow*
Divya Vohora, *New Delhi*
Devdatta Suhas Neogi, *Mumbai*
Mohamed Shafi, *Tamil Nadu State*
Pankaj Kumar, *Andhra Pradesh*
Pramod V Lokhande, *Pune*
Vidyadhara Srinivasa, *Karnataka*
Vaibhav Bagaria, *Ghaziabad*

Iran

Hossein Negahban, *Ahvaz*
Sayed Javad Mousavi, *Tehran*

Ireland

Joseph S Butler, *Dublin*

Israel

Alexander Blankstein, *Ramat Hasharon*
Dror Lakstein, *Haifa*
Itzhak Binderman, *Tel Aviv*
Nahum Rosenberg, *Haifa*
Youssef Maher Masharawi, *Tel Aviv*

Italy

Alessandro Geraci, *Feltre*
Angelo Cacchio, *L'Aquila*
Costantino Errani, *Bologna*
Claudia Mazzà, *Roma*
Donatella Lippi, *Florence*
Giuseppe M Campo, *Messina*
Giuseppe Banfi, *Milano*
Patrizia D'Amelio, *Torino*
Marco Crostelli, *Rome*
Marcello Maggio, *Parma*
Marco Giuseppe Angelo Teli, *Bergamo*
Monica Mattioli-Belmonte, *Ancona*
Marco Monticone, *Lissone*
Pasquale De Negri, *Rionero in Vulture*
Andrea Giusti, *Genova*
Alberto Gobbi, *Milan*
Raoul Saggini, *Chieti*
Saverio Affatato, *Bologna*
Tomaso Villa, *Milano*

Japan

Akio Sakamoto, *Fukuoka*
Jun Iwamoto, *Tokyo*
Kanji Mori, *Otsu*
Makoto Makishima, *Tokyo*
Ryuichi Morishita, *Suita*
Shuichi Kaneyama, *Kobe*
Tadahiko Yotsumoto, *Osaka*
Toru Yamaguchi, *Izumo-shi*
Toshimasa Uemura, *Ibaraki*
Hideki Nagashima, *Yonago*
Hisataka Yasuda, *Nagahama*
Yasuharu Nagano, *Saitama*
Yoichi Aota, *Yokohama*
Yuichi Kasai, *Tsu city*

Morocco

Abdellah El Maghraoui, *Rabat*

Netherlands

Claudine JC Lamoth, *Groningen*
Barend J van Royen, *Amsterdam*
Doug King, *Lower Hutt*
Paul C Jutte, *Groningen*
PE Huijsmans, *Hague*
PM van der Kraan, *Nijmegen*
Michel van den Bekerom, *Amsterdam*
JJ Verlaan, *Utrecht*
Rob GHH Nelissen, *Leiden*
Taco Gosens, *Tilburg*

Norway

Jan Oxholm Gordeladze, *Oslo*
Gunnar Knutsen, *Tromsø*

Portugal

João F Mano, *Guimarães*

Serbia

Radica Dunjic, *Belgrade*
Miroslav Z Milankov, *Novi Sad*
Zoran Vukasinovic, *Belgrade*

Singapore

Anselm Mak, *Singapore*
Dongan Wang, *Singapore*
V Prem Kumar, *Singapore*

South Korea

Dae-Geun Jeon, *Seoul*
Seok Woo Kim, *Gyeonggi*
Sang-Hun Ko, *Ulsan*
Sung-Uk Kuh, *Seoul*
Jaebeom Lee, *Miryang*
Yong Seuk Lee, *Suwon*
Hyun Woo Kim, *Seoul*
Jae Taek Hong, *Suwon*
Jong-Beom Park, *Kyunggi-do*
Kook Jin Chung, *Seoul*
Kyu Hyun Yang, *Seoul*
Sang Ki Lee, *Daejeon*

Spain

Antonio Herrera, *Zaragoza*
Daniel Hernandez Vaquero, *Aviles*
Francisco J Blanco, *A Coruña*
Nuria Vilaboa, *Madrid*

Sri Lanka

Janaka Lenora, *Galle*

Sweden

Jan G Jakobsson, *Stockholm*
Anna Nordström, *Umeå*

Switzerland

Achim Elfering, *Bern*
Benjamin Gantenbein, *Bern*

Nicola A Maffiuletti, *Zurich*
Michael Hirschmann, *Basel*
Elyazid Mouhsine, *Lausanne*
Peter Fennema, *Baar*

Thailand

Boonsin Tangtrakulwanich, *Songkla*
Prachya Kongtawelert, *Chiang Mai*
Sittisak Honsawek, *Bangkok*

Tunisia

Lamia Rezgui-Marhoul, *Tunis*

Turkey

Akmer Mutlu, *Ankara*
Bulent Daglar, *Ankara*
Kemal NAS, *Diyarbakır*
Salih Özgöçmen, *Kayseri*
Serdar Kahraman, *İstanbul*

United Kingdom

Henry DE Atkinson, *London*
Vikas Khanduja, *Cambridge*
Ali Mobasheri, *Sutton Bonington*
Charles Anthony Willis-Owen, *London*
Vikki Wylde, *Bristol*
Tosan Okoro, *Bangor*

United States

Srino Bharam, *New York*
Craig R Bottoni, *Honolulu*
Lavjay Butani, *Sacramento*
Chaoyang Chen, *Detroit*
Ock K Chun, *Storrs*
Christopher J Colloca, *Chandler*
Nabanita S Datta, *Detroit*
Paul E Di Cesare, *Sacramento*
Matthew B Dobbs, *Saint Louis*
Evan F Fkman, *Columbia*
Joel J Gagnier, *Ann Arbor*
Federico P Girardi, *New York*
David L Helfet, *New York*
Johnny Huard, *Pittsburgh*
Stefan Judex, *Stony Brook*
Monroe Laborde, *New Orleans*
Bingyun Li, *Morgantown*
Subburaman Mohan, *Loma Linda*
Arash Momeni, *Palo Alto*
Nader D Nader, *Buffalo*
John Nyland, *Louisville*
Karin Grävare Silbernagel, *Newark*
David H Song, *Chicago*
Nelson F SooHoo, *Los Angeles*
SPA Stawicki, *Columbus*
Ann Marie Swank, *Louisville*
R Shane Tubbs, *Birmingham*
Victoria M Virador, *Bethesda*
Savio LY Woo, *Pittsburgh*
Masayoshi Yamaguchi, *Atlanta*
Feng-Chun Yang, *Indianapolis*
Subhashini Yaturu, *Albany*
Hiroki Yokota, *Troy*
Charalampos Zalavras, *Los Angeles*
Chunfeng Zhao, *Rochester*
Anil Bhave, *Baltimore*
John Elias, *Akron*
Clark Dickin, *Muncie*
John S Early, *Dallas*
James S Harrop, *Philadelphia*
Adam H Hsieh, *Maryland*
Aditya V Maheshwari, *New York*
Zong-Ming Li, *Cleveland*
Richard M Lovering, *Baltimore*
Lyle Joseph Micheli, *Boston*
Ming Pei, *Morgantown*
Juan A Pretell – Mazzini, *Philadelphia*
David M Selkowitz, *Pomona*
Hassan Serhan, *Raynham*
Subhashini Yaturu, *Albany*
Sorin Siegler, *Pennsylvania*
Aaron David Sciascia, *Lexington*
Jeffrey C Wang, *Santa Monica*
David Andrew Spiegel, *Philadelphia*
Inna Belfer, *Pittsburgh*
Angie Botto-van Bemden, *Lauderdale*
Quan-Jun Cui, *Virginia*
Scott D Daffner, *Morgantown*
B Sonny Bal, *Columbia*
Beril Gok, *Baltimore*
Ashraf S Gorgey, *Richmond*
Kee D Kim, *Sacramento*
Brian Michael Haus, *Boston*
Dror Paley, *Pittsburgh*
Bing Wang, *Pittsburgh*
Wen-Bao Wang, *New York*
Li-Qun Zhang, *Chicago*
Nigel Zheng, *Charlotte*

WJO World Journal of Orthopedics

Contents

Monthly Volume 3 Number 2 February 18, 2012

BRIEF ARTICLE

10 Innervation of cervical ventral facet joint capsule: Histological evidence
Kallakuri S, Li Y, Chen CY, Cavanaugh JM

15 Measurement of forces generated during distraction of growing-rods in early onset scoliosis
Teli M, Grava G, Solomon V, Andreoletti G, Grismondi E, Meswania J

World Journal of Orthopedics
Volume 3 Number 2 February 18, 2012

Contents

ACKNOWLEDGMENTS	I	Acknowledgments to reviewers of *World Journal of Orthopedics*
APPENDIX	I	Meetings
	I-V	Instructions to authors
ABOUT COVER		Kallakuri S, Li Y, Chen CY, Cavanaugh JM. Innervation of cervical ventral facet joint capsule: Histological evidence. *World J Orthop* 2012; 3(2): 10-14 http://www.wjgnet.com/2218-5836/full/v3/i2/10.htm
AIM AND SCOPE		*World Journal of Orthopedics* (*World J Orthop*, *WJO*, online ISSN 2218-5836, DOI: 10.5312) is a monthly peer-reviewed, online, open-access, journal supported by an editorial board consisting of 261 experts in orthopedics from 30 countries. The aim of *WJO* is to report rapidly new theories, methods and techniques for prevention, diagnosis, treatment, rehabilitation and nursing in the field of orthopedics. *WJO* covers diagnostic imaging, arthroscopy, evidence-based medicine, epidemiology, nursing, sports medicine, therapy of bone and spinal diseases, bone trauma, osteoarthropathy, bone tumors and osteoporosis, minimally invasive therapy, traditional medicine, and integrated Chinese and Western medicine. The journal also publishes original articles and reviews that report the results of applied and basic research in fields related to orthopedics, such as immunology, physiopathology, cell biology, pharmacology, medical genetics, and pharmacology of Chinese herbs.
FLYLEAF	I-II	Editorial Board

NAME OF JOURNAL
World Journal of Orthopedics

ISSN
ISSN 2218-5836 (online)

LAUNCH DATE
November 18, 2010

FREQUENCY
Monthly

EDITING
Editorial Board of *World Journal of Orthopedics*
Room 903, Building D, Ocean International Center,
No. 62 Dongsihuan Zhonglu, Chaoyang District,
Beijing 100025, China
Telephone: +86-10-85381892
Fax: +86-10-85381893
E-mail: wjo@wjgnet.com
http://www.wjgnet.com

EDITOR-IN-CHIEF
Bao-Gan Peng, MD, PhD, Professor, Department of Spinal Surgery, General Hospital of Armed Police Force, 69 Yongding Road, Beijing 100039, China

EDITORIAL OFFICE
Xiao-Cui Yang, Assistant Director
World Journal of Orthopedics
Room 903, Building D, Ocean International Center,
No. 62 Dongsihuan Zhonglu, Chaoyang District,
Beijing 100025, China
Telephone: +86-10-85381892
Fax: +86-10-85381893
E-mail: wjo@wjgnet.com
http://www.wjgnet.com

PUBLISHER
Baishideng Publishing Group Co., Limited
Room 1701, 17/F, Henan Building,
No.90 Jaffe Road, Wanchai, Hong Kong, China
Fax: +852-31158812
Telephone: +852-58042046
E-mail: bpg@baishideng.com
http://www.wjgnet.com

PUBLICATION DATE
February 18, 2012

INSTRUCTIONS TO AUTHORS
Full instructions are available online at http://www.wjgnet.com/2218-5836/g_info_20100722172650.htm

ONLINE SUBMISSION
http://www.wjgnet.com/2218-5836office/

World Journal of Orthopedics

Online Submissions: http://www.wjgnet.com/2218-5836office
wjo@wjgnet.com
doi:10.5312/wjo.v3.i2.10

World J Orthop 2012 February 18; 3(2): 10-14
ISSN 2218-5836 (online)

BRIEF ARTICLE

Innervation of cervical ventral facet joint capsule: Histological evidence

Srinivasu Kallakuri, Yan Li, Chaoyang Chen, John M Cavanaugh

Srinivasu Kallakuri, Yan Li, Chaoyang Chen, John M Cavanaugh, Department of Biomedical Engineering, Wayne State University, 818 W Hancock, Detroit, MI 48201, United States
Author contributions: Kallakuri S contributed to the study design, harvesting samples, performing staining procedures and preparation of the manuscript; Li Y contributed in performing immunostaining; Chen CY contributed to tissue harvesting and manuscript preparation; Cavanaugh JM contributed to the study design, manuscript preparation and review.
Supported by Grants from Centers for Disease Control to Cavanaugh JM, No. R49-CCR519751 and R49-CE000455
Correspondence to: Srinivasu Kallakuri, PhD, Department of Biomedical Engineering, Wayne State University, 818 W Hancock, Detroit, MI 48201, United States. skallakuri@wayne.edu
Telephone: +1-313-5773440 Fax: +1-313-5778333
Received: August 19, 2011 Revised: November 22, 2011
Accepted: February 16, 2012
Published online: February 18, 2012

Abstract

AIM: To assess the presence of nerves in ventral facet joint capsules as facet capsules are generally implicated in neck pain.

METHODS: Twenty-four ventral cervical facet joint capsules were harvested from 3 unembalmed cadavers. Paraffin sections from these capsules were processed to identify neurofilament and substance P immunoreactive fibers. Nerve fiber presence was also verified by a silver impregnation method.

RESULTS: Neurofilament reactive fibers were observed in sections from 9 capsules. They were observed in areas with collagen fibers and areas with irregular connective tissue. Substance P reactive nerve fibers were found in sections from 7 capsules in similar areas. Silver impregnation also revealed the presence of nerve fibers. The nerve fibers were also found as bundles in the lateral margins of the capsule. A Pacinian corpuscle-like ending was also observed in one specimen.

CONCLUSION: Nerve fibers revealed by neurofilament immunoreactivity and silver staining support innervation of the ventral aspect of the facet joint capsule. The presence of substance P reactive fibers supports the potential role of these elements in mediating pain. The presence of a Pacinian-like ending implicates a potential role in joint movement.

Key words: Cervical facet joint capsule; Whiplash; Nerve fibers; Neurofilament; Substance P; Pain

Peer reviewers: Marco Giuseppe Angelo Teli, MD, Department of Orthopaedics, Policlinico San Marco, Corso Europa 7, 20035 Osio Sotto-Bergamo, Italy; Marios Georgios Lykissas, MD, PhD, Department of Orthopaedic Surgery, University of Ioannina School of Medicine Dourouti, Ioannina, PC 45110, Greece

Kallakuri S, Li Y, Chen CY, Cavanaugh JM. Innervation of cervical ventral facet joint capsule: Histological evidence. *World J Orthop* 2012; 3(2): 10-14 Available from: URL: http://www.wjgnet.com/2218-5836/full/v3/i2/10.htm DOI: http://dx.doi.org/10.5312/wjo.v3.i2.10

INTRODUCTION

According to a United Nations Transport division report, the total annual cost of rear impact whiplash injuries has been estimated to be approximately $ 2.7 billion in the United States, with an estimated 272 464 annual injuries. Whiplash associated disorders (WAD) to the neck are common and can occur during frontal, side and rear-end impacts, but most complaints occur after a rear-end collision by another vehicle. Studies by Aprill and Bogduk[1], Barnsley *et al*[2] and Lord *et al*[3] provide clinical evidence for the role of cervical facet joints in the etiol-

ogy of neck pain with several other studies providing biomechanical evidence[4,5]. It has been hypothesized that in a rear impact, the facet joints slide with the posterior-most regions of the joints undergoing compression more than the anterior-most regions, resulting in a pinching or capsular stretch mechanism that may be related to neck pain[5,6].

Additionally, the role of cervical osteoarthritis as a contributing factor to neck pain and other upper extremity painful conditions related to arms and shoulders can not be ignored. An analysis on the progression rates of cervical osteoarthritis from a cohort of 707 subjects showed that women were more likely to experience worsening of their disease compared to men[7], while a recent anatomical and epidemiological study of cadaveric spines revealed concurrent lumbar and cervical arthrosis as a common condition, suggesting an underlying systemic component for spinal osteoarthritis[8].

The cervical facet joint capsules (FJCs) are innervated by medial branches of the dorsal ramus[9]. Igarashi *et al*[10] suggested that inflammatory cytokines produced in degenerated facet joints may leak into the intra-spinal space through the most lateral part of the ventral FJC. Evidence for the presence of inflammatory cytokines was demonstrated in homogenates of degenerated lumbar facet joint cartilage and synovial tissues harvested from patients undergoing posterior lumbar surgery, while evidence for leakage was shown by stained ventral facet joint capsule and lateral ligamentum flavum following methylene blue injection into the degenerated dorsal facet joint. Therefore degenerative changes in the ventral cervical facet joints capsule may lead to a painful sensation in the neck and surrounding areas.

Thus, previous research indicates that the ventral aspect of the cervical FJC can undergo degenerative and inflammatory changes which can lead to a sensation of pain in the neck. However, studies focused on the innervation of ventral areas of FJC have not been published and the available studies are limited to innervation of the dorsal aspect of the cervical FJC[11] or the synovial fold[12]. Hence, the purpose of this study was to characterize the presence of nerve fibers in the ventral cervical FJCs by immunocytochemical and silver impregnation methods.

MATERIALS AND METHODS

A total of 24 ventral facet joint capsules from C1/C2-C6/C7 were harvested from the cervical spines of 3 unembalmed cadavers. One (female; 73 years) was donated as part of the Willed Body Program to the institution for other biomechanical studies and the other two (56 year old female and 44 old male) were procured from the National Disease Research Interchange (NDRI, Philadelphia, PA). All procedures were approved by the institutional Human and Animal Investigation Committee. The harvested capsules were fixed (4% paraformaldehyde) and processed for paraffin infiltration and sectioning (10-15 μm; Reichert Yung, Leica Microsystems Nussloch GmbH, Nussloch). These sections were deparaffinized and cleared in xylene and graded alcohol and washed thoroughly in distilled water and processed for a silver impregnation technique and avidin biotin peroxidase immunocytochemistry.

Silver impregnation technique

A Palmgren silver impregnation technique was used to visualize nerve fibers in the ventral FJC sections. The sections were incubated in a solution of 10% silver nitrate for 30 min at 37 ℃ and then were transferred to 2% sodium borate and then thoroughly washed. This was followed by developing for 10 min in 0.05 g hydroquinone and 5.0 g sodium sulphite dissolved in 100 mL of freshly prepared solution of 2% sodium borate. The sections were then rinsed in 50% alcohol, treated for 60 s to 70 s in 0.5% oxalic acid in 50% alcohol, rinsed in distilled water and then fixed for 10 s in 5% sodium thiosulphate. Finally, the sections were rinsed in distilled water, dehydrated in graded alcohol, xylene and cover-slipped.

Immunocytochemistry

The sections were incubated in 4% hydrogen peroxide to block endogenous peroxide activity, followed by blocking in 2% normal goat serum (Vector Laboratories, Burlingame, CA). The sections were then incubated overnight in 1:500 diluted antisera to neurofilament light chain (NF; AB9568, Millipore, CA), 1:200 diluted antisera to substance P (SP, Millipore, CA) at 4 ℃. This was followed by incubation in biotinylated secondary antibodies before being exposed to Vectastain Elite ABC reagent (Vector Laboratories). After each step, the sections were rinsed three times in phosphate buffered saline (PBS). The reaction product was then developed by brief incubation in 3, 3'-diaminobenzidine and hydrogen peroxide. The sections were then washed, counterstained with hematoxylin and dehydrated through graded alcohol, cleared in xylene, and cover-slipped with permount.

A total of 90 slides were stained for immunocytochemistry and 60 for silver staining, respectively. The sections were analyzed to determine the presence or absence of nerve fibers but not for quantitative comparisons. All the stained sections were observed under a light microscope (Leica DMLB, Leica Microsystems Ltd., Heerburg, Switzerland) attached to a digital camera system (Diagnostic Instruments Inc., Sterling Heights, MI).

RESULTS

Sections of the ventral facet joint capsule have parallel bundles of collagen fibers and areas of irregular connective tissue. Also found were areas with adipose-like connective tissue. Neurofilament (NF) reactive fibers were observed in sections from 9 capsules at levels C2/C3-C5/C6. They were observed as single fibers and in groups of 2 or 3 fibers (Figure 1). The NF-reactive fibers were observed to be in areas of joint capsule with

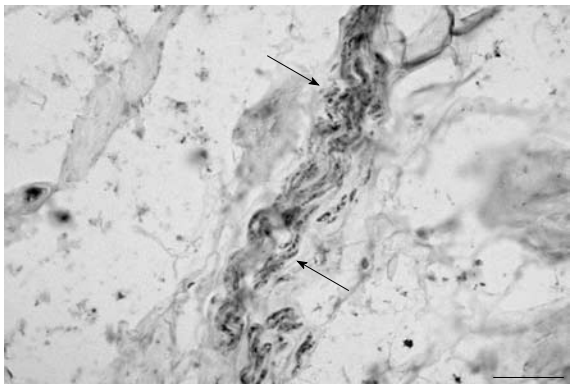


Figure 1 A bundle of neurofilament reactive nerve fibers in a C3-C4 ventral facet joint capsular tissue (scale bar = 50 μm).

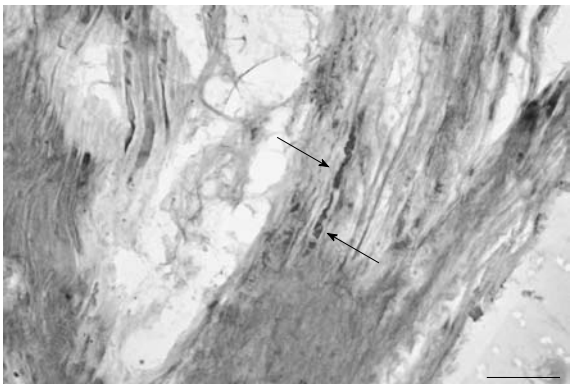


Figure 3 A nerve fiber revealed by a silver impregnation technique in the collagen fibers of a C4-C5 facet joint capsule (scale bar = 50 μm).

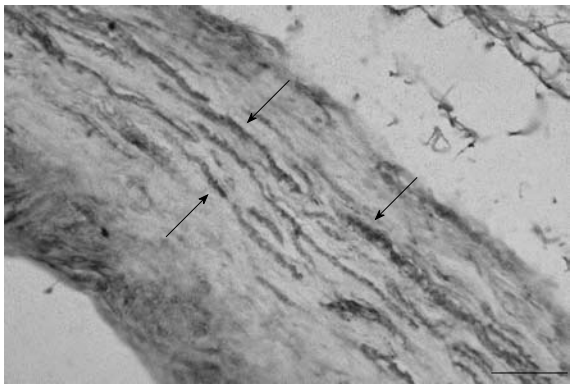


Figure 2 A series of substance P reactive fibers in a C2-C3 ventral facet joint capsular tissue (scale bar = 50 μm).

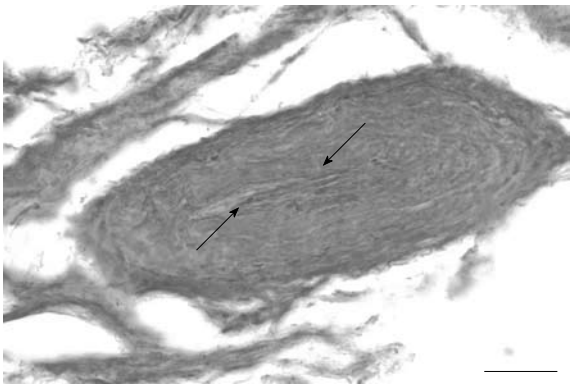


Figure 4 A Pacinian-like end organ in the ventral facet joint capsular tissue (scale bar = 50 μm).

collagen fibers as well as in areas with irregular connective tissue. Some of the NF reactive regions appeared as a chain of beads with intermittent staining.

Substance P (SP) reactive nerve fibers were found in areas with parallel bundles of collagen fibers as well as in areas with irregular connective tissue from 7 capsules at levels C2/3-C5/6. Additionally, SP reactive fibers were observed to be both as single fibers (Figure 2) and in bundles, similar to those found with NF reactivity.

Silver impregnation results

Silver impregnation also revealed the presence of short and long nerve fibers in capsule sections with parallel bundles of collagen fibers, as well as in areas with dense irregular connective tissue (Figure 3). The nerve fibers appeared to be running parallel to the collagen fibers and occasionally showed profiles of dotted staining. The nerve fibers were also found as bundles in the lateral margins of the capsule. There also appeared to be a nerve profile that resembled an encapsulated nerve ending composed of groups of fibers surrounded by a ring-like Pacinian-type end organ (Figure 4).

DISCUSSION

There is ample clinical[2,3,13,14] and biomechanical[15,16] evidence of the role of cervical FJC in the etiology of neck pain. Neurophysiological studies in goat cervical spine showed activation of low threshold mechanoreceptors at low strains and high threshold mechanoreceptors at high strains[17] on the dorsal aspect of the capsule. While several studies showed innervation of the dorsal aspect of cervical FJC[11,12,18,19] or to the synovial fold[12,19,20], the results of the current study provide histological evidence to the presence of neural elements on the ventral aspect of cervical FJC.

In the current study, no systematic effort was made to study the morphology of cervical FJC. Although the samples were harvested from only 3 cadavers, nerve fibers were identified in the ventral aspect of sections from all three cadavers in a total of 10 facet joints. In the present study, sections of the ventral aspect of the cervical facet joint capsule showed areas of parallel bundles of collagen fibers and areas with irregular connective tissue. This may be similar to the findings of Yamashita *et al*[21] who described an outer layer of densely packed parallel bundles of collagen fibers and inner layer with loose connective tissue with irregularly oriented fibers[21]. This study also showed areas in some sections where collagen fibers were associated with adipose-like tissue that may be similar to fat filled intra-capsular folds present in the lumbar facet joint capsules[22] or adipose plical tissue.

Bogduk *et al*[9] provided some of the most detailed descriptions of the anatomy of the dorsal rami and their supply of nerve fibers to the cervical FJC through the medial branch and reports the space ventral to the joint as being free of articular nerves in the cervical region. Bogduk[23] did not report any specific articular branches to the ventral aspect of the lumbar zygapophyseal joint but eludes to the findings of others. Whether these findings from the lumbar region can be extended to the cervical region remains to be investigated. However, our present study provides strong evidence for the presence of nerve fibers in the ventral FJC by the presence of NF immunoreactive nerve fibers and bundles in various layers of the capsule. This was further supported by the silver stained nerve fibers. However, a clear neuroanatomical description on the origin of ventral articular fibers still remains elusive.

Despite these limitations, innervation of the ventral aspect of the capsule has clinical implications. If these nerve fibers do not originate from the dorsal ramus, dorsal ramus rhizotomy would be ineffective in the treatment of pain from this area. In addition, facet injections may not provide anesthesia to the ventral capsule. Finally, effectiveness of epidural steroids may be partially related to its effects on the ventral capsule.

This study also shows SP reactive fibers in the ventral cervical FJC, lending credence to its putative role as a source of pain-related sensation. This may be important in the context of inflammatory pain originating from cervical FJC. In a recent study, Igarashi *et al*[10] showed higher visual analog and Roland-Morris disability questionnaire scores in patients with lumbar spinal canal stenosis that co-related with high levels of IL1ß. They concluded that inflammatory cytokines produced in a degenerated facet joint may leak into the intraspinal space through the lateral part of the ventral FJC, based on leakage of dorsally injected methylene blue dye that stained the joint cartilage, ventral capsule and other surrounding structures in cadavers.

In a recent study, Ivancic[24] showed that exposing FJC in cervical spine preparations to elongations at a rate of 1 mm/s in increments of 0.5 mm can lead to increased laxity and indicated that this increased laxity may be one of the components perpetuating chronic pain clinical instability in whiplash patients. Biomechanical evidence on ventral capsular kinematics comes from Stemper *et al*[15] who subjected intact head and neck complexes to whiplash accelerations and analyzed shear and distraction motions in ventral and dorsal joint regions from C4-C7 levels. They showed lower cervical facet joints undergoing dorsally directed shear motion with distraction in the ventral and compression in the dorsal regions of the joint. Facet joint shear and distraction motion increased with impact severity. They suggested that the ventral region responded with greater magnitudes of stretch. Moreover, high levels of capsule stretch may also be related to altered axonal morphological changes (axonal swellings) similar to those reported in cervical dorsal facet joint capsule[25]. Axonal swellings and retraction balls are characteristic of diffuse axonal injury seen in patients of TBI. Finally, a Pacinian-like end organ in some layers of the ventral FJC was also found, which may be similar to the findings of McLain[18] who also reported encapsulated and simple or free nerve endings in the human cervical FJC subsynovial loose areolar and dense connective tissue. Presence of Pacinian-like end organs may indicate that ventral FJC may be involved in responding to high velocity changes in joint position.

Key message

Prominent NF and SP reactive fibers in the ventral cervical FJC suggest a nociceptive function and a putative role for ventral FJC in the etiology of neck pain following whiplash injury, inflammatory conditions and spondylosis.

COMMENTS

Background

Whiplash associated disorders to the neck are common and can occur during frontal, side and rear-end impacts, but most complaints occur after a rear-end collision by another vehicle. The role of cervical facet joint capsules (FJC) in whiplash has been widely implicated by both clinical and biomechanical studies. Although the presence of nerve fibers on the dorsal capsule has been reported in several studies, histological evidence revealing their presence on the ventral aspect is lacking.

Research frontiers

There is extensive clinical and biomechanical evidence on the role of cervical FJC in the etiology of neck pain. Neurophysiological studies in goat cervical spine showed activation of low threshold mechanoreceptors at low strains and high threshold mechanoreceptors at high strains on the dorsal aspect of the capsule. While several studies showed innervation of the dorsal aspect of cervical FJC or to the synovial fold, studies related to the presence of nerve fibers on the ventral aspect are lacking. It is possible that the ventral aspect of the cervical FJC can undergo degenerative and inflammatory changes which can lead to a sensation of pain in the neck.

Innovations and breakthroughs

Previous studies have shown innervation of dorsal facet capsule. This is the first histological study to document ventral capsule innervation. The presence of nerve fibers is supported by neurofilament immunoreactive fibers as well as those shown by silver staining.

Applications

This study offers support for the potential role for ventral facet joint capsules in the etiology of neck pain following whiplash injury, inflammatory conditions and spondylosis.

Terminology

Whiplash: Rapid flexion and extension of the neck during frontal and rear-end impacts. Substance P: A neuropeptide involved in pain signaling.

Peer review

This is a very interesting topic that has been focused on. It is a very well written manuscript with a good educational point of view and will be a good contribution for publication in the journal.

REFERENCES

1 **Aprill C**, Bogduk N. The prevalence of cervical zygapophyseal joint pain. A first approximation. *Spine (Phila Pa 1976)* 1992; **17**: 744-747
2 **Barnsley L**, Lord SM, Wallis BJ, Bogduk N. The prevalence of chronic cervical zygapophysial joint pain after whiplash. *Spine (Phila Pa 1976)* 1995; **20**: 20-5; discussion 26
3 **Lord SM**, Barnsley L, Wallis BJ, Bogduk N. Chronic cervical zygapophysial joint pain after whiplash. A placebo-

controlled prevalence study. *Spine (Phila Pa 1976)* 1996; **21**: 1737-144; discussion 1737-144;
4 **Deng B**, Begeman P, Yang K, Tashman S, King AI. Kinematics of human cadaver cervical spine during low speed rear-end impacts. Proceedings of the 44th Stapp Car Crash Conference, 2000: 171-188
5 **Yoganandan N**, Pintar FA, Cusick JF. Biomechanical analyses of whiplash injuries using an experimental model. *Accid Anal Prev* 2002; **34**: 663-671
6 **Yang KH**, Begeman PC, Muser M, Niederer P, Waltz F. On the role of cervical facet joints in rear end impact neck injury mechanisms. *Society for Automotive Engineers* 1997: 970497
7 **Wilder FV**, Fahlman L, Donnelly R. Radiographic cervical spine osteoarthritis progression rates: a longitudinal assessment. *Rheumatol Int* 2011; **31**: 45-48
8 **Master DL**, Eubanks JD, Ahn NU. Prevalence of concurrent lumbar and cervical arthrosis: an anatomic study of cadaveric specimens. *Spine (Phila Pa 1976)* 2009; **34**: E272-E275
9 **Bogduk N**. The clinical anatomy of the cervical dorsal rami. *Spine (Phila Pa 1976)* 1982; **7**: 319-330
10 **Igarashi A**, Kikuchi S, Konno S. Correlation between inflammatory cytokines released from the lumbar facet joint tissue and symptoms in degenerative lumbar spinal disorders. *J Orthop Sci* 2007; **12**: 154-160
11 **Kallakuri S**, Singh A, Chen C, Cavanaugh JM. Demonstration of substance P, calcitonin gene-related peptide, and protein gene product 9.5 containing nerve fibers in human cervical facet joint capsules. *Spine (Phila Pa 1976)* 2004; **29**: 1182-1186
12 **Inami S**, Shiga T, Tsujino A, Yabuki T, Okado N, Ochiai N. Immunohistochemical demonstration of nerve fibers in the synovial fold of the human cervical facet joint. *J Orthop Res* 2001; **19**: 593-596
13 **Manchikanti L**, Boswell MV, Singh V, Pampati V, Damron KS, Beyer CD. Prevalence of facet joint pain in chronic spinal pain of cervical, thoracic, and lumbar regions. *BMC Musculoskelet Disord* 2004; **5**: 15
14 **Manchikanti L**, Manchikanti KN, Pampati V, Brandon DE, Giordano J. The prevalence of facet-joint-related chronic neck pain in postsurgical and nonpostsurgical patients: a comparative evaluation. *Pain Pract* 2008; **8**: 5-10
15 **Stemper BD**, Yoganandan N, Pintar FA. Gender- and region-dependent local facet joint kinematics in rear impact: implications in whiplash injury. *Spine (Phila Pa 1976)* 2004; **29**: 1764-1771
16 **Quinn KP**, Winkelstein BA. Cervical facet capsular ligament yield defines the threshold for injury and persistent joint-mediated neck pain. *J Biomech* 2007; **40**: 2299-2306
17 **Lu Y**, Chen C, Kallakuri S, Patwardhan A, Cavanaugh JM. Neural response of cervical facet joint capsule to stretch: a study of whiplash pain mechanism. *Stapp Car Crash J* 2005; **49**: 49-65
18 **McLain RF**. Mechanoreceptor endings in human cervical facet joints. *Spine (Phila Pa 1976)* 1994; **19**: 495-501
19 **Giles LG**, Harvey AR. Immunohistochemical demonstration of nociceptors in the capsule and synovial folds of human zygapophyseal joints. *Br J Rheumatol* 1987; **26**: 362-364
20 **Vandenabeele F**, Creemers J, Lambrichts I, Robberechts W. Fine structure of vesiculated nerve profiles in the human lumbar facet joint. *J Anat* 1995; **187** (Pt 3): 681-692
21 **Yamashita T**, Minaki Y, Ozaktay AC, Cavanaugh JM, King AI. A morphological study of the fibrous capsule of the human lumbar facet joint. *Spine (Phila Pa 1976)* 1996; **21**: 538-543
22 **Taylor JR**, McCormick CC. Lumbar facet joint fat pads: their normal anatomy and their appearance when enlarged. *Neuroradiology* 1991; **33**: 38-42
23 **Bogduk N**. The innervation of the lumbar spine. *Spine (Phila Pa 1976)* 1983; **8**: 286-293
24 **Ivancic PC**, Ito S, Tominaga Y, Rubin W, Coe MP, Ndu AB, Carlson EJ, Panjabi MM. Whiplash causes increased laxity of cervical capsular ligament. *Clin Biomech (Bristol, Avon)* 2008; **23**: 159-165
25 **Kallakuri S**, Singh A, Lu Y, Chen C, Patwardhan A, Cavanaugh JM. Tensile stretching of cervical facet joint capsule and related axonal changes. *Eur Spine J* 2008; **17**: 556-563

S- Editor Yang XC **L- Editor** Roemmele A **E- Editor** Yang XC

World Journal of Orthopedics

Online Submissions: http://www.wjgnet.com/2218-5836office
wjo@wjgnet.com
doi:10.5312/wjo.v3.i2.15

World J Orthop 2011 February 18; 3(2): 15-19
ISSN 2218-5836 (online)

BRIEF ARTICLE

Measurement of forces generated during distraction of growing-rods in early onset scoliosis

Marco Teli, Giuseppe Grava, Victor Solomon, Giuseppe Andreoletti, Emanuele Grismondi, Jay Meswania

Marco Teli, Consultant Orthopaedic Surgeon, Orthopaedic Spine Unit, Policlinico San Marco, Corso Europa 7, 24040 Osio Sotto, Bergamo, Italy
Giuseppe Grava, Victor Solomon, Giuseppe Andreoletti, Consultant Orthopaedic Surgeon, Orthopaedic Department, Policlinico San Marco, Corso Europa 7, 24040 Osio Sotto, Bergamo, Italy
Emanuele Grismondi, Staff Grade Surgeon, Orthopaedic Department, Policlinico San Marco, Corso Europa 7, 24040 Osio Sotto, Bergamo, Italy
Jay Meswania, Biomedical Engineer, Royal National Orthopaedic Hospital, Stanmore, United Kingdom
Author contributions: Teli M and Meswania J designed and obtained the experimental data; Meswania J put the data into charts and did the analysis; Teli M, Grava G, Solomon V, Andreoletti G and Grismondi E revised the data and wrote the text.
Correspondence to: Dr. Marco Teli, Consultant Orthopaedic Surgeon, Orthopaedic Spine Unit, Policlinico San Marco, Residence Grancia, Via Tevere 7, 20020 Lainate, Milano, Italy. marcoteli@hotmail.com
Telephone: +39-02-93559100 Fax: +39-0331-449459
Received: August 19, 2011 Revised: December 28, 2011
Accepted: February 16, 2012
Published online: February 18, 2012

Abstract

AIM: To measure the forces applied during distraction of growing-rods in early onset scoliosis (EOS), aimed at developing a motorized elongation device.

METHODS: A consecutive series of measurements were carried out to analyze the forces applied by the surgeon during distraction of single growing-rods in 10 patients affected by EOS (mean age 8.3 years; range 6 to 10 years) undergoing the first distraction 6 months following implantation of the rods. For each measurement, output from the transducer of a dedicated pair of distraction calipers was recorded at zero load status and at every 1 mm of distraction, up to a maximum of 12 mm for each of the two connected rods.

RESULTS: Twenty measurements were obtained showing a linear increase of the load with increasing distraction, with a mean peak force of 485 N at 12 mm distraction and a single reading over 500 N. We did not observe bone fractures or ligament disruptions during or after rod elongations. There was one case of superficial wound infection in the cohort.

CONCLUSION: The safe peak force carrying capacity of a motorized device for distraction of growing-rods is 500N.

Key words: Early onset scoliosis; Spinal deformity; Growing-rods; Spinal elongation; Force measurement

Peer reviewer: Yong Hu, PhD, Assistant Professor, Department of Orthopaedics and Traumatology, The University of Hong Kong 12 Sandy Bay Road, Hong Kong, China

Teli M, Grava G, Solomon V, Andreoletti G, Grismondi E, Meswania J. Measurement of forces generated during distraction of growing-rods in early onset scoliosis. *World J Orthop* 2012; 3(2): 15-19 Available from: URL: http://www.wjgnet.com/2218-5836/full/v3/i2/15.htm DOI: http://dx.doi.org/10.5312/wjo.v3.i2.15

INTRODUCTION

Early onset scoliosis (EOS) is a deformity of the growing spine, affecting children before the age of complete lung maturation, i.e., 8 years to 10 years. Growing children with progressive spinal deformity resistant to casting and/or bracing have been treated for four decades with "spinal instrumentation without fusion" or growing-rods. The term encompasses a range of posterior spinal instrumentation techniques – namely single or dual growing rods and expandable ribs, pursuing the

common goal of progressive deformity correction without halting the growth of the spine and lungs[1].

Paul Harrington[2] in 1962 described the use of a single, threaded growing-rod on the concave side of the deformity, reporting poor results due to spontaneous fusion and a 11% incidence of rod failure. Marchetti *et al*[3] later added end vertebrae fusion to limit rod displacement without reporting definitive results. Luque described the use of two rods with segmental wiring without the necessity for any external support[4]. For this technique, which is still in use with modifications[5], variable percentages of success and implant failure are reported. Moe *et al*[6] developed the use of a sub-cutaneous growing-rod in an attempt to limit the incidence of implant failure and infection. They achieved good mean curvature control and a 3.8 cm mean spinal growth (SG) at follow-up, at the expense of a 50% rod failure and 15% infection rate. Klemme *et al*[7] reported on the use of a sub-fascial rod and achieved 3.1 cm mean SG, with an 8% rod failure and a 15% infection rate. Mineiro *et al*[8] reported on the results of sub-cutaneous growing rods (with or without anterior apical fusion) and achieved 2.0 cm mean SG, with 42% rod failure and 9% infection rates. Finally, Akbarnia *et al*[9] reported on the use of two parallel growing-rods implanted sub-fascially with a connector for periodic lengthening, achieving 4.6 cm mean SG, with a 22% rate of implant failure and a 9% rate of deep infection. With all growing-rods techniques, the child needs to undergo repeated surgeries, at intervals of 6 mo to 9 mo[1], and once maximum spinal growth has been reached, definitive spinal fusion is performed. It is arguable, from the review of the literature and our own experience with the technique, that limiting the number of open surgeries would decrease the incidence of infection and limit the risks correlated with repeated general anesthesia. To this end, Takaso *et al*[10] tested a motorized device for closed growing-rod distraction on a canine model of induced scoliosis. Near-complete correction was obtained in awake animals by remote-controlled rod distraction at 3 wk intervals, with a pre-tested distraction peak force of the device of 194 N. If similar devices are to be designed and applied in clinical use, it is necessary to measure the force pattern generated during surgical distraction of growing-rods. The aim of this study was therefore to measure and analyze the pattern of such forces in children affected by EOS.

MATERIALS AND METHODS

Ten children affected by EOS resistant to conservative treatment underwent scheduled surgical distractions of single growing-rods, 6 mo after first implantation and distraction. The sample group consisted of 4 males and 6 females aged on average 8.3 years (range 6 years to 10 years) at the time of surgery. Etiologies of deformities included idiopathic scoliosis in 4 cases, syndromic scoliosis in 3 cases, post-surgical scoliosis in 2 cases and arthrogyposis multiplex congenital (AMC) in 1 case. Surgeries were consecutively performed at a single center for spinal diseases by a team of spinal deformity surgeons. All patients' were skeletally immature at the time of surgery, as demonstrated by spinal posteroanterior X-rays (absence of ossification of both the iliac apophyses and the triradiate cartilages). Prior to the present surgery, growing rods had been implanted in sub-fascial position on the concavity of the coronal curvature[1,2,6-8]. Stainless steel 4.5 mm diameter pediatric Cotrel-Dobousset rods (Medtronic Sofamor Danek, Inc., Memphis TN, United States) had been used in all patients. Laminar hooks and/or pedicle screws had been used at the bottom end vertebrae and laminar plus pedicle hooks at the top ones, in a claw-like configuration (Figure 1). End vertebrae had been decorticated and no bone graft was added locally to enhance fusion. Following the first implantation, patients had been kept on molded plastic braces until the scheduled distraction. Local fusion performed at the end vertebrae was assessed by postero-anterior and lateral full spine radiographs prior to the scheduled distraction. No patient had had an anterior growth-arrest procedure.

A special pair of distraction calipers similar to those commercially available was manufactured, incorporating a load transducer to allow the measurement of force applied at the tip of the calipers. Included in the design was a millimeter scaled ruler (Figure 2). The calipers were load tested and calibrated to demonstrate repeatability, with accuracy of less than 1% of the full scale deflection. The accuracy of the displacement measurement using a ruler in a surgical environment was considered to be ± 0.25 mm. Output from the transducer was recorded by dedicated software and represented as a load-displacement (distraction) plot (Figure 3).

For the distraction of growing-rods, patients were positioned prone under general anesthesia and monitoring of somatosensory spinal evoked potentials. The rod connector and 50 mm of each rod were exposed through a centered skin incision and opening of the fascia. This was followed by serial loosening of the connector locking nuts and placement of the distraction calipers against a firm rod-holder. As the first rod started to be distracted, output from the transducer was recorded at zero load and at every 1mm increment up to the greatest distraction achievable until the limit of 12 mm[9-11]. A 10 s sample interval was observed in order to allow for the visco-elastic properties of the spinal soft tissues to act[9-11]. This process was repeated for the second rod, measuring the output from the transducer. After the elongation was completed, new nuts were tightened to the rod connector and wound closure was performed in layers. Patients were mobilized in their braces as soon as tolerated and discharged without exception on the day following surgery.

RESULTS

A total of 20 force measurements were performed during rod distraction on the ten patients. Table 1 displays

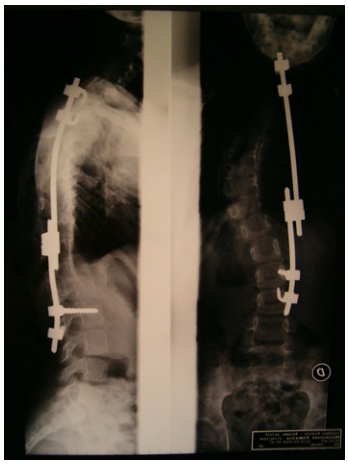


Figure 1 Lateral and postero-anterior spinal films after implantation of growing-rods.

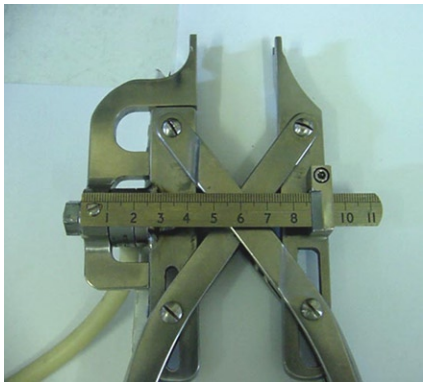


Figure 2 Distraction calipers.

features of pre and post-distraction spinal deformities as mean ± SD values. The mean 19.2 mm total distraction was the result of the elongation of both rods until a maximum of 12 mm per rod. The elongation of each rod stopped when the surgeon reached 12 mm and/or maximum effort had been transferred to the elongation. Minimal corrections were obtained in Cobb angles, indicating that first distractions mainly re-tension implants on a growing spine[1-3,6-8]. Table 2 displays the minimum, mean and maximum forces per millimeter of rod distraction. Tension forces ranged from a mean of 133 N at 1 mm distraction to a mean of 485 N at 12 mm distraction. The tension force reached a maximum of 552 N at 6mm distraction of one of the two rods in the patient affected by AMC.

Figure 3 shows how the minimum, mean and maximum forces steadily increased with distraction of the rods up to the above reported peak. The graph also indicates that there was a pre-load on the rod that needed to be overcome before any elongation could be achieved. Once the pre-load was overcome, there appeared to be a linear relationship between the load and elongation. Notably, the surgeon needed to apply mean forces of similar magnitude to achieve 10 mm and 12 mm of distraction. In 7 out of 10 measurements, the upper limit

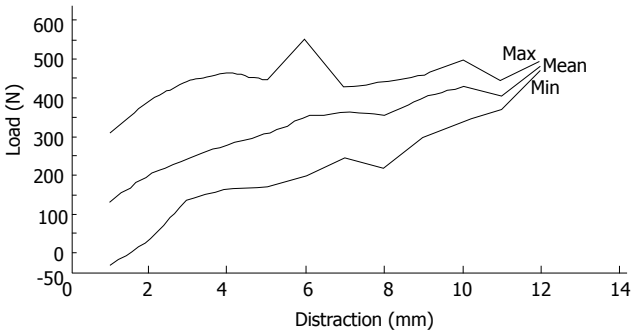


Figure 3 Force/distraction plot: maximum (top curve), mean (middle curve) and minimum (bottom curve) values.

of distraction for a single rod was 10 mm.

These experimental data corresponded clinically to a small improvement in both the coronal and sagittal mean spinal deformity angles (3.6° and 4.4° respectively, $P < 0.05$, Student's paired t test), and to a satisfactory 19.2 mm mean lengthening of the implants obtained with surgery (Table 1).

There were no instances of fracture of the posterior vertebral elements or implant failure during or after distraction. One out of the 10 cases had delayed wound healing that required one week of oral antibiotic treatment after S. Epidermidis was grown from the wound culture. There were no instances of neurological deficits or medical complications after surgery in the cohort.

DISCUSSION

Infection and implant failure are the two main limitations of the current growing-rod techniques[1-9]. It is easy to understand how the first issue might greatly benefit from limiting the number of open surgeries that patients need to undergo in order to achieve progressive correction and spinal growth. Implant failure, seemingly a function of the length of treatment with growing rods, may be due to rod loosening or indirectly to fracture of the posterior elements, mainly the laminae[8,9]. Possibly, this problem could be also addressed by distracting the growing-rod system non-surgically at closer intervals than the 6 mo to 9 mo routine[1,10]. Developing a closed distraction mechanism ready for clinical use, as it was the case with extendible endoprostheses in limb tumor surgery[11], could be one of the steps towards better results of spinal instrumentation without fusion in the treatment of early onset scoliosis. To do so, it was necessary to measure the magnitude of the forces generated *in vivo* by a surgeon distracting a growing-rod system.

No data have been reported prior to this study on the magnitude of the forces generated during distraction of growing-rods in children. It is known however that the load to failure of a thoracic lamina instrumented with a hook is around 670 N in the adolescent[12] and that recommended values of distraction force with Harrington instrumentation did not exceed 400 N[13]. In our patients, growing-rods were positioned on the concavity of the

Table 1 Spinal deformity angles

	Mean	SD	*P* value (*t* - test)
Pre-distraction PA cobb	53.8	19.9	
Post-distraction PA cobb	50.2	20	0.003
Pre-distraction Lat cobb	46.2	13.7	
Post-distraction Lat cobb	41.8	13.5	0.006
Rods distraction (mm)	19.2	4.4	

Table 2 Force/distraction values

Distraction (mm)	Min. load (N)	Mean load (N)	Max. load (N)
1 (min)	-32 (min)	133 (min)	311 (min)
2	30	203	394
3	141	247	447
4	167	282	465
5	172	308	447
6	201	354	552 (max)
7	246	364	428
8	222	354	440
9	303	402	461
10	342	430	497
11	370	404	445
12 (max)	472 (max)	485 (max)	498

scoliotic curve like Harrington rods, and the attachment to bone was *via* pedicle screws or laminar hooks at the bottom levels, lower thoracic or lumbar, and *via* laminar and pedicle hooks at the upper thoracic levels. Therefore, it is possible to compare our mean peak distraction force of 485 N with that of the above studies. As described above, the recorded peak force exceeded the 500 N threshold in a single patient with the likely reason that soft tissues in patients affected by AMC have peculiar mechanical properties[14]. Also, a negative force of –32 N was recorded at minimum distraction in a single case. This could be due to the fact that very little load is normally applied in a confined space like that occupied by the distraction tool. These factors might limit the significance of the results of the study.

Despite applying forces of this magnitude, in our series there was no failure of the bone-implant interface and good maintenance of deformity with satisfactory spinal elongation. Not surprisingly, small improvements in deformity angles have been observed with distractions in this study, because the main correction normally takes place at the time of the first implantation[1-9].

Transferring the experimental data described in the study to the development of a motorized device for closed distraction would take into account several factors: firstly, the position of the rods with respect to the concavity of the curve; and secondly, the load transfers from the rods to the vertebral bone and the presence of friction within the device itself. The device would be made of two rods connected via a central gear housing an electrical motor to replicate the force vector obtained with positioning of the single growing-rods. The bone-implant interface will replicate the pedicle screws and claw-like hooks design described above (Figure 1). Finally, we estimate that the magnitude of the forces measured during growing-rods distraction certainly includes any frictional losses in the locking mechanisms that will be taken up by the motorized system. Therefore, we would recommend the peak force carrying capacity of a motorized device for growing-rod extension not to exceed the mean level of 485 N measured in this study.

COMMENTS

Background

The treatment of early onset scoliosis is surgical when resistant to casts and braces and progressive. Growing-rods are often used but need repeated open surgeries to achieve their effect.

Research frontiers

Growing-rods are normally elongated every 6-8 mo according to spinal growth. Closed elongation procedures are not applied today because (1) no data existed on the forces involved *in vivo* before the present study was undertaken; and (2) technology of closed elongation had only been applied to mammals in the laboratory.

Innovations and breakthroughs

It is now known that the forces applied in elongation of growing rods in children affected by early onset scoliosis reach a maximum level of 500 N, with a pattern that reproduces the visco-elastic features of the human spine.

Applications

Data retrieved by this study can be applied to the development of a closed, motorized elongation growing-rod system to save children affected by early onset scoliosis from repeated surgeries.

Terminology

Early onset scoliosis is a spinal deformity that develops before the age of lung maturation (8 years to 10 years) and that can impair lung development for the rest of life. Growing-rods are a particular form of spinal instrumentation that allows correction of spinal deformity while allowing lung and spinal growth.

Peer review

This is a valuable article with good performances.

REFERENCES

1 **Thompson GH**, Akbarnia BA, Campbell RM. Growing rod techniques in early-onset scoliosis. *J Pediatr Orthop* 2007; **27**: 354-361

2 **HARRINGTON PR**. Treatment of scoliosis. Correction and internal fixation by spine instrumentation. *J Bone Joint Surg Am* 1962; **44-A**: 591-610

3 **Marchetti PG**, Faldini A. End fusion in the treatment of some progressing or severe scoliosis in childhood or early adolescence. *Orthop Trans* 1978: **2**: 271

4 **Luque ER**. Paralytic scoliosis in growing children. *Clin Orthop Relat Res* 1982; **163**: 202-209

5 **Pratt RK**, Webb JK, Burwell RG, Cummings SL. Luque trolley and convex epiphysiodesis in the management of infantile and juvenile idiopathic scoliosis. *Spine (Phila Pa 1976)* 1999; **24**: 1538-1547

6 **Moe JH**, Kharrat K, Winter RB, Cummine JL. Harrington instrumentation without fusion plus external orthotic support for the treatment of difficult curvature problems in young children. *Clin Orthop Relat Res* 1984; **185**: 35-45

7 **Klemme WR**, Denis F, Winter RB, Lonstein JW, Koop SE. Spinal instrumentation without fusion for progressive scoliosis in young children. *J Pediatr Orthop* 1997; **17**: 734-742

8 **Mineiro J**, Weinstein SL. Subcutaneous rodding for progressive spinal curvatures: early results. *J Pediatr Orthop* 2002; **22**: 290-295

9 **Akbarnia BA**, Marks DS, Boachie-Adjei O, Thompson AG, Asher MA. Dual growing rod technique for the treatment of

progressive early-onset scoliosis: a multicenter study. *Spine (Phila Pa 1976)* 2005; **30**: S46-S57

10 **Takaso M**, Moriya H, Kitahara H, Minami S, Takahashi K, Isobe K, Yamagata M, Otsuka Y, Nakata Y, Inoue M. New remote-controlled growing-rod spinal instrumentation possibly applicable for scoliosis in young children. *J Orthop Sci* 1998; **3**: 336-340

11 **Schindler OS**, Cannon SR, Briggs TW, Blunn GW. Stanmore custom-made extendible distal femoral replacements. Clinical experience in children with primary malignant bone tumours. *J Bone Joint Surg Br* 1997; **79**: 927-937

12 **Waugh TR**. Intravital measurements during instrumental correction of idiopathic scoliosis. *Acta Orthop Scand* 1966; **93S**: Suppl 93: 1-9387

13 **Dunn HK**, Daniels AU, McBride GG. Intraoperative force measurements during correction of scoliosis. *Spine (Phila Pa 1976)* 1982; **7**: 448-455

14 **Yingsakmongkol W**, Kumar SJ. Scoliosis in arthrogryposis multiplex congenita: results after nonsurgical and surgical treatment. *J Pediatr Orthop* 2000; **20**: 656-661

S- Editor Yang XC **L- Editor** Roemmele A **E- Editor** Yang XC

World Journal of Orthopedics

Online Submissions: http://www.wjgnet.com/2218-5836office
wjo@wjgnet.com
www.wjgnet.com

World J Orthop 2012 February 18; 3(2): I
ISSN 2218-5836 (online)

Acknowledgments to reviewers of *World Journal of Orthopedics*

Many reviewers have contributed their expertise and time to the peer review, a critical process to ensure the quality of *World Journal of Orthopedics*. The editors and authors of the articles submitted to the journal are grateful to the following reviewers for evaluating the articles (including those published in this issue and those rejected for this issue) during the last editing time period.

Yong Hu, PhD, Assistant Professor, Department of Orthopaedics and Traumatology, The University of Hong Kong, 12 Sandy Bay Road, Hong Kong, China

Marios Georgios Lykissas, MD, PhD, Department of Orthopaedic Surgery, University of Ioannina School of Medicine Dourouti, Ioannina, PC 45110, Greece

Marco Giuseppe Angelo Teli, MD, Department of Orthopaedics, Policlinico San Marco, Corso Europa 7, 20035 Osio Sotto–Bergamo, Italy

World Journal of Orthopedics

Online Submissions: http://www.wjgnet.com/2218-5836office
wjo@wjgnet.com
www.wjgnet.com

World J Orthop 2012 February 18; 3(2): I
ISSN 2218-5836 (online)

Events Calendar 2012

January 12-15, 2012
ICJR 4th Annual Winter Hip and Knee Course
Colorado, CO, United States

January 23-25, 2012
8th Middle East Orthopaedics Conference "Future Challenges and Directions in Orthopedic Surgery"
Dubai, United Arab Emirates

February 7-11, 2012
American Academy of Orthopaedic Surgeons
San Diego, CA, United States

February 14-15, 2012
7th National Conference: Orthopaedics and Sports Medicine 2012 London, United Kingdom

February 16-19, 2012
Orthopaedic MRI and Small Parts
Scottsdale, AZ, United States

March 4-8, 2012
The 30th Annual Emergencies in Medicine Conference
Utah, UT, United States

March 8-10, 2012
ICJR 2nd Annual Advances in Orthopaedic Trauma and Arthroplasty Course
Florida, FL, United States

March 17-24, 2012
Orthopaedics and Sports Medicine for Primary Care Practitioners
Honolulu, HI, United States

May 2-6, 2012
Association of Bone and Joint Surgeons
Charleston, SC, United States

May 4-5, 2012
8th Annual Spine Care Conference for the Primary Care Practitioner
Sacramento, CA, United States

May 9-11, 2012
Pan-African Orthopaedics Conference 2012
Nasrec, South Africa

May 11-21, 2012
Rheumatology and Orthopaedics
Civitavecchia, Italy

July 8-15, 2012
Practice Management and Technology for The 21st Century Practice
Lauderdale, FL, United States

August 13-15, 2012
International Conference and Exhibition on Orthopedics
Chicago, IL, United States

September 14-21, 2012
Orthopaedics and Sports Medicine
Barcelona, Spain

September 21-25, 2012
36th Annual UC Davis Fingers to the Toes Comprehensive Review of Primary Care Orthopaedics
Lake Tahoe, CA, United States

World Journal of Orthopedics

Online Submissions: http://www.wjgnet.com/2218-5836office
wjo@wjgnet.com
www.wjgnet.com

World J Orthop 2012 February 18; 3(2): I-V
ISSN 2218-5836 (online)

GENERAL INFORMATION

World Journal of Orthopedics (*World J Orthop*, *WJO*, online ISSN 2218-5836, DOI: 10.5312) is a monthly peer-reviewed, online, open-access (OA), journal supported by an editorial board consisting of 261 experts in orthopedics from 30 countries.

The biggest advantage of the OA model is that it provides free, full-text articles in PDF and other formats for experts and the public without registration, which eliminates the obstacle that traditional journals possess and usually delays the speed of the propagation and communication of scientific research results. The open access model has been proven to be a true approach that may achieve the ultimate goal of the journals, i.e. the maximization of the value to the readers, authors and society.

Maximization of personal benefits

The role of academic journals is to exhibit the scientific levels of a country, a university, a center, a department, and even a scientist, and build an important bridge for communication between scientists and the public. As we all know, the significance of the publication of scientific articles lies not only in disseminating and communicating innovative scientific achievements and academic views, as well as promoting the application of scientific achievements, but also in formally recognizing the "priority" and "copyright" of innovative achievements published, as well as evaluating research performance and academic levels. So, to realize these desired attributes of *WJO* and create a well-recognized journal, the following four types of personal benefits should be maximized. The maximization of personal benefits refers to the pursuit of the maximum personal benefits in a well-considered optimal manner without violation of the laws, ethical rules and the benefits of others. (1) Maximization of the benefits of editorial board members: The primary task of editorial board members is to give a peer review of an unpublished scientific article via online office system to evaluate its innovativeness, scientific and practical values and determine whether it should be published or not. During peer review, editorial board members can also obtain cutting-edge information in that field at first hand. As leaders in their field, they have priority to be invited to write articles and publish commentary articles. We will put peer reviewers' names and affiliations along with the article they reviewed in the journal to acknowledge their contribution; (2) Maximization of the benefits of authors: Since *WJO* is an open-access journal, readers around the world can immediately download and read, free of charge, high-quality, peer-reviewed articles from *WJO* official website, thereby realizing the goals and significance of the communication between authors and peers as well as public reading; (3) Maximization of the benefits of readers: Readers can read or use, free of charge, high-quality peer-reviewed articles without any limits, and cite the arguments, viewpoints, concepts, theories, methods, results, conclusion or facts and data of pertinent literature so as to validate the innovativeness, scientific and practical values of their own research achievements, thus ensuring that their articles have novel arguments or viewpoints, solid evidence and correct conclusion; and (4) Maximization of the benefits of employees: It is an iron law that a first-class journal is unable to exist without first-class editors, and only first-class editors can create a first-class academic journal. We insist on strengthening our team cultivation and construction so that every employee, in an open, fair and transparent environment, could contribute their wisdom to edit and publish high-quality articles, thereby realizing the maximization of the personal benefits of editorial board members, authors and readers, and yielding the greatest social and economic benefits.

Aims and scope

The aim of *WJO* is to report rapidly new theories, methods and techniques for prevention, diagnosis, treatment, rehabilitation and nursing in the field of orthopedics. *WJO* covers diagnostic imaging, arthroscopy, evidence-based medicine, epidemiology, nursing, sports medicine, therapy of bone and spinal diseases, bone trauma, osteoarthropathy, bone tumors and osteoporosis, minimally invasive therapy, traditional medicine, and integrated Chinese and Western medicine. The journal also publishes original articles and reviews that report the results of applied and basic research in fields related to orthopedics, such as immunology, physiopathology, cell biology, pharmacology, medical genetics, and pharmacology of Chinese herbs.

Columns

The columns in the issues of *WJO* will include: (1) Editorial: To introduce and comment on major advances and developments in the field; (2) Frontier: To review representative achievements, comment on the state of current research, and propose directions for future research; (3) Topic Highlight: This column consists of three formats, including (A) 10 invited review articles on a hot topic, (B) a commentary on common issues of this hot topic, and (C) a commentary on the 10 individual articles; (4) Observation: To update the development of old and new questions, highlight unsolved problems, and provide strategies on how to solve the questions; (5) Guidelines for Basic Research: To provide Guidelines for basic research; (6) Guidelines for Clinical Practice: To provide guidelines for clinical diagnosis and treatment; (7) Review: To review systemically progress and unresolved problems in the field, comment on the state of current research, and make suggestions for future work; (8) Original Articles: To report innovative and original findings in orthopedics; (9) Brief Articles: To briefly report the novel and innovative findings in orthopedics; (10) Case Report: To report a rare or typical case; (11) Letters to the Editor: To discuss and make reply to the contributions published in *WJO*, or to introduce and comment on a controversial issue of general interest; (12) Book Reviews: To introduce and comment on quality monographs of orthopedics; and (13) Guidelines: To introduce consensuses and guidelines reached by international and national academic authorities worldwide on the research orthopedics.

Name of journal

World Journal of Orthopedics

ISSN

ISSN 2218-5836 (online)

Editor-in-chief

Editorial Office

World Journal of Orthopedics
Editorial Department: Room 903, Building D,
Ocean International Center,

No. 62 Dongsihuan Zhonglu,
Chaoyang District, Beijing 100025, China
E-mail: wjo@wjgnet.com
http://www.wjgnet.com
Telephone: +86-10-8538-1892
Fax: +86-10-8538-1893

Indexed and Abstracted in
PubMed Central, PubMed, Digital Object Identifer and Directory of Open Access Journals.

Published by
Baishideng Publishing Group Co., Limited

SPECIAL STATEMENT

All articles published in this journal represent the viewpoints of the authors except where indicated otherwise.

Biostatistical editing
Statisital review is performed after peer review. We invite an expert in Biomedical Statistics from to evaluate the statistical method used in the paper, including *t*-test (group or paired comparisons), chi-squared test, Ridit, probit, logit, regression (linear, curvilinear, or stepwise), correlation, analysis of variance, analysis of covariance, *etc.* The reviewing points include: (1) Statistical methods should be described when they are used to verify the results; (2) Whether the statistical techniques are suitable or correct; (3) Only homogeneous data can be averaged. Standard deviations are preferred to standard errors. Give the number of observations and subjects (*n*). Losses in observations, such as drop-outs from the study should be reported; (4) Values such as ED50, LD50, IC50 should have their 95% confidence limits calculated and compared by weighted probit analysis (Bliss and Finney); and (5) The word 'significantly' should be replaced by its synonyms (if it indicates extent) or the *P* value (if it indicates statistical significance).

Conflict-of-interest statement
In the interests of transparency and to help reviewers assess any potential bias, *WJO* requires authors of all papers to declare any competing commercial, personal, political, intellectual, or religious interests in relation to the submitted work. Referees are also asked to indicate any potential conflict they might have reviewing a particular paper. Before submitting, authors are suggested to read "Uniform Requirements for Manuscripts Submitted to Biomedical Journals: Ethical Considerations in the Conduct and Reporting of Research: Conflicts of Interest" from International Committee of Medical Journal Editors (ICMJE), which is available at: http://www.icmje.org/ethical_4conflicts.html.

Sample wording: [Name of individual] has received fees for serving as a speaker, a consultant and an advisory board member for [names of organizations], and has received research funding from [names of organization]. [Name of individual] is an employee of [name of organization]. [Name of individual] owns stocks and shares in [name of organization]. [Name of individual] owns patent [patent identification and brief description].

Statement of informed consent
Manuscripts should contain a statement to the effect that all human studies have been reviewed by the appropriate ethics committee or it should be stated clearly in the text that all persons gave their informed consent prior to their inclusion in the study. Details that might disclose the identity of the subjects under study should be omitted. Authors should also draw attention to the Code of Ethics of the World Medical Association (Declaration of Helsinki, 1964, as revised in 2004).

Statement of human and animal rights
When reporting the results from experiments, authors should follow the highest standards and the trial should conform to Good Clinical Practice (for example, US Food and Drug Administration Good Clinical Practice in FDA-Regulated Clinical Trials; UK Medicines Research Council Guidelines for Good Clinical Practice in Clinical Trials) and/or the World Medical Association Declaration of Helsinki. Generally, we suggest authors follow the lead investigator's national standard. If doubt exists whether the research was conducted in accordance with the above standards, the authors must explain the rationale for their approach and demonstrate that the institutional review body explicitly approved the doubtful aspects of the study.

Before submitting, authors should make their study approved by the relevant research ethics committee or institutional review board. If human participants were involved, manuscripts must be accompanied by a statement that the experiments were undertaken with the understanding and appropriate informed consent of each. Any personal item or information will not be published without explicit consents from the involved patients. If experimental animals were used, the materials and methods (experimental procedures) section must clearly indicate that appropriate measures were taken to minimize pain or discomfort, and details of animal care should be provided.

SUBMISSION OF MANUSCRIPTS

Manuscripts should be typed in 1.5 line spacing and 12 pt. Book Antiqua with ample margins. Number all pages consecutively, and start each of the following sections on a new page: Title Page, Abstract, Introduction, Materials and Methods, Results, Discussion, Acknowledgements, References, Tables, Figures, and Figure Legends. Neither the editors nor the publisher are responsible for the opinions expressed by contributors. Manuscripts formally accepted for publication become the permanent property of Baishideng Publishing Group Co., Limited, and may not be reproduced by any means, in whole or in part, without the written permission of both the authors and the publisher. We reserve the right to copy-edit and put onto our website accepted manuscripts. Authors should follow the relevant guidelines for the care and use of laboratory animals of their institution or national animal welfare committee. For the sake of transparency in regard to the performance and reporting of clinical trials, we endorse the policy of the ICMJE to refuse to publish papers on clinical trial results if the trial was not recorded in a publicly-accessible registry at its outset. The only register now available, to our knowledge, is http://www.clinicaltrials.gov sponsored by the United States National Library of Medicine and we encourage all potential contributors to register with it. However, in the case that other registers become available you will be duly notified. A letter of recommendation from each author's organization should be provided with the contributed article to ensure the privacy and secrecy of research is protected.

Authors should retain one copy of the text, tables, photographs and illustrations because rejected manuscripts will not be returned to the author(s) and the editors will not be responsible for loss or damage to photographs and illustrations sustained during mailing.

Online submissions
Manuscripts should be submitted through the Online Submission System at: http://www.wjgnet.com/2218-5836office. Authors are highly recommended to consult the ONLINE INSTRUCTIONS TO AUTHORS (http://www.wjgnet.com/2218-5836/g_info_20100722172650.htm) before attempting to submit online. For assistance, authors encountering problems with the Online Submission System may send an email describing the problem to wjo@wjgnet.com, or by telephone: +86-10-85381892. If you submit your manuscript online, do not make a postal contribution. Repeated online submission for the same manuscript is strictly prohibited.

MANUSCRIPT PREPARATION

All contributions should be written in English. All articles must be submitted using word-processing software. All submissions must be typed in 1.5 line spacing and 12 pt. Book Antiqua with ample margins.

Style should conform to our house format. Required information for each of the manuscript sections is as follows:

Title page

Title: Title should be less than 12 words.

Running title: A short running title of less than 6 words should be provided.

Authorship: Authorship credit should be in accordance with the standard proposed by International Committee of Medical Journal Editors, based on (1) substantial contributions to conception and design, acquisition of data, or analysis and interpretation of data; (2) drafting the article or revising it critically for important intellectual content; and (3) final approval of the version to be published. Authors should meet conditions 1, 2, and 3.

Institution: Author names should be given first, then the complete name of institution, city, province and postcode. For example, Xu-Chen Zhang, Li-Xin Mei, Department of Pathology, Chengde Medical College, Chengde 067000, Hebei Province, China. One author may be represented from two institutions, for example, George Sgourakis, Department of General, Visceral, and Transplantation Surgery, Essen 45122, Germany; George Sgourakis, 2nd Surgical Department, Korgialenio-Benakio Red Cross Hospital, Athens 15451, Greece

Author contributions: The format of this section should be: Author contributions: Wang CL and Liang L contributed equally to this work; Wang CL, Liang L, Fu JF, Zou CC, Hong F and Wu XM designed the research; Wang CL, Zou CC, Hong F and Wu XM performed the research; Xue JZ and Lu JR contributed new reagents/analytic tools; Wang CL, Liang L and Fu JF analyzed the data; and Wang CL, Liang L and Fu JF wrote the paper.

Supportive foundations: The complete name and number of supportive foundations should be provided, e.g. Supported by National Natural Science Foundation of China, No. 30224801

Correspondence to: Only one corresponding address should be provided. Author names should be given first, then author title, affiliation, the complete name of institution, city, postcode, province, country, and email. All the letters in the email should be in lower case. A space interval should be inserted between country name and email address. For example, Montgomery Bissell, MD, Professor of Medicine, Chief, Liver Center, Gastroenterology Division, University of California, Box 0538, San Francisco, CA 94143, United States. montgomery.bissell@ucsf.edu

Telephone and fax: Telephone and fax should consist of +, country number, district number and telephone or fax number, e.g. Telephone: +86-10-59080039 Fax: +86-10-85381893

Peer reviewers: All articles received are subject to peer review. Normally, three experts are invited for each article. Decision for acceptance is made only when at least two experts recommend an article for publication. Reviewers for accepted manuscripts are acknowledged in each manuscript, and reviewers of articles which were not accepted will be acknowledged at the end of each issue. To ensure the quality of the articles published in *WJO*, reviewers of accepted manuscripts will be announced by publishing the name, title/position and institution of the reviewer in the footnote accompanying the printed article. For example, reviewers: Professor Jing-Yuan Fang, Shanghai Institute of Digestive Disease, Shanghai, Affiliated Renji Hospital, Medical Faculty, Shanghai Jiaotong University, Shanghai, China; Professor Xin-Wei Han, Department of Radiology, The First Affiliated Hospital, Zhengzhou University, Zhengzhou, Henan Province, China; and Professor Anren Kuang, Department of Nuclear Medicine, Huaxi Hospital, Sichuan University, Chengdu, Sichuan Province, China.

Abstract

There are unstructured abstracts (no less than 256 words) and structured abstracts (no less than 480). The specific requirements for structured abstracts are as follows:

An informative, structured abstracts of no less than 480 words should accompany each manuscript. Abstracts for original contributions should be structured into the following sections. AIM (no more than 20 words): Only the purpose should be included. Please write the aim as the form of "To investigate/study/…"; MATERIALS AND METHODS (no less than 140 words); RESULTS (no less than 294 words): You should present *P* values where appropriate and must provide relevant data to illustrate how they were obtained, e.g. 6.92 ± 3.86 *vs* 3.61 ± 1.67, $P < 0.001$; CONCLUSION (no more than 26 words).

Key words

Please list 5-10 key words, selected mainly from *Index Medicus*, which reflect the content of the study.

Text

For articles of these sections, original articles and brief articles, the main text should be structured into the following sections: INTRODUCTION, MATERIALS AND METHODS, RESULTS and DISCUSSION, and should include appropriate Figures and Tables. Data should be presented in the main text or in Figures and Tables, but not in both. The main text format of these sections, editorial, topic highlight, case report, letters to the editors, can be found at: http://www.wjgnet.com/2218-5836/g_info_list.htm.

Illustrations

Figures should be numbered as 1, 2, 3, *etc.*, and mentioned clearly in the main text. Provide a brief title for each figure on a separate page. Detailed legends should not be provided under the figures. This part should be added into the text where the figures are applicable. Figures should be either Photoshop or Illustrator files (in tiff, eps, jpeg formats) at high-resolution. Examples can be found at: http://www.wjgnet.com/1007-9327/13/4520.pdf; http://www.wjgnet.com/1007-9327/13/4554.pdf; http://www.wjgnet.com/1007-9327/13/4891.pdf; http://www.wjgnet.com/1007-9327/13/4986.pdf; http://www.wjgnet.com/1007-9327/13/4498.pdf. Keeping all elements compiled is necessary in line-art image. Scale bars should be used rather than magnification factors, with the length of the bar defined in the legend rather than on the bar itself. File names should identify the figure and panel. Avoid layering type directly over shaded or textured areas. Please use uniform legends for the same subjects. For example: Figure 1 Pathological changes in atrophic gastritis after treatment. A: ...; B: ...; C: ...; D: ...; E: ...; F: ...; G: …*etc.* It is our principle to publish high resolution-figures for the printed and E-versions.

Tables

Three-line tables should be numbered 1, 2, 3, *etc.*, and mentioned clearly in the main text. Provide a brief title for each table. Detailed legends should not be included under tables, but rather added into the text where applicable. The information should complement, but not duplicate the text. Use one horizontal line under the title, a second under column heads, and a third below the Table, above any footnotes. Vertical and italic lines should be omitted.

Notes in tables and illustrations

Data that are not statistically significant should not be noted. $^{a}P < 0.05$, $^{b}P < 0.01$ should be noted ($P > 0.05$ should not be noted). If there are other series of *P* values, $^{c}P < 0.05$ and $^{d}P < 0.01$ are used. A third series of *P* values can be expressed as $^{e}P < 0.05$ and $^{f}P < 0.01$. Other notes in tables or under illustrations should be expressed as ^{1}F, ^{2}F, ^{3}F; or sometimes as other symbols with a superscript (Arabic numerals) in the upper left corner. In a multi-curve illustration, each curve should be labeled with ●, ○, ■, □, ▲, △, *etc.*, in a certain sequence.

Acknowledgments

Brief acknowledgments of persons who have made genuine contributions to the manuscript and who endorse the data and conclusions should be included. Authors are responsible for obtaining written permission to use any copyrighted text and/or illustrations.

REFERENCES

Coding system

The author should number the references in Arabic numerals according to the citation order in the text. Put reference numbers in square brackets in superscript at the end of citation content or after the cited author's name. For citation content which is part of the narration, the coding number and square brackets should be typeset normally. For example, "Crohn's disease (CD) is associated with increased intestinal permeability[1,2]". If references are cited directly in the text, they should be put together within the text, for example, "From references[19,22-24], we know that...".

When the authors write the references, please ensure that the order in text is the same as in the references section, and also ensure the spelling accuracy of the first author's name. Do not list the same citation twice.

PMID and DOI

Pleased provide PubMed citation numbers to the reference list, e.g. PMID and DOI, which can be found at http://www.ncbi.nlm.nih.gov/sites/entrez?db=pubmed and http://www.crossref.org/SimpleTextQuery/, respectively. The numbers will be used in E-version of this journal.

Style for journal references

Authors: the name of the first author should be typed in bold-faced letters. The family name of all authors should be typed with the initial letter capitalized, followed by their abbreviated first and middle initials. (For example, Lian-Sheng Ma is abbreviated as Ma LS, Bo-Rong Pan as Pan BR). The title of the cited article and italicized journal title (journal title should be in its abbreviated form as shown in PubMed), publication date, volume number (in black), start page, and end page [PMID: 11819634 DOI: 10.3748/wjg.13.5396].

Style for book references

Authors: the name of the first author should be typed in bold-faced letters. The surname of all authors should be typed with the initial letter capitalized, followed by their abbreviated middle and first initials. (For example, Lian-Sheng Ma is abbreviated as Ma LS, Bo-Rong Pan as Pan BR) Book title. Publication number. Publication place: Publication press, Year: start page and end page.

Format

Journals

English journal article (list all authors and include the PMID where applicable)

1 **Jung EM**, Clevert DA, Schreyer AG, Schmitt S, Rennert J, Kubale R, Feuerbach S, Jung F. Evaluation of quantitative contrast harmonic imaging to assess malignancy of liver tumors: A prospective controlled two-center study. *World J Gastroenterol* 2007; **13**: 6356-6364 [PMID: 18081224 DOI: 10.3748/wjg.13.6356]

Chinese journal article (list all authors and include the PMID where applicable)

2 **Lin GZ**, Wang XZ, Wang P, Lin J, Yang FD. Immunologic effect of Jianpi Yishen decoction in treatment of Pixu-diarrhoea. *Shijie Huaren Xiaohua Zazhi* 1999; **7**: 285-287

In press

3 **Tian D**, Araki H, Stahl E, Bergelson J, Kreitman M. Signature of balancing selection in Arabidopsis. *Proc Natl Acad Sci USA* 2006; In press

Organization as author

4 **Diabetes Prevention Program Research Group**. Hypertension, insulin, and proinsulin in participants with impaired glucose tolerance. *Hypertension* 2002; **40**: 679-686 [PMID: 12411462 PMCID:2516377 DOI:10.1161/01.HYP.0000035706.28494.09]

Both personal authors and an organization as author

5 **Vallancien G**, Emberton M, Harving N, van Moorselaar RJ; Alf-One Study Group. Sexual dysfunction in 1, 274 European men suffering from lower urinary tract symptoms. *J Urol* 2003; **169**: 2257-2261 [PMID: 12771764 DOI:10.1097/01.ju.0000067940.76090.73]

No author given

6 21st century heart solution may have a sting in the tail. *BMJ* 2002; **325**: 184 [PMID: 12142303 DOI:10.1136/bmj.325.7357.184]

Volume with supplement

7 **Geraud G**, Spierings EL, Keywood C. Tolerability and safety of frovatriptan with short- and long-term use for treatment of migraine and in comparison with sumatriptan. *Headache* 2002; **42** Suppl 2: S93-99 [PMID: 12028325 DOI:10.1046/j.1526-4610.42.s2.7.x]

Issue with no volume

8 **Banit DM**, Kaufer H, Hartford JM. Intraoperative frozen section analysis in revision total joint arthroplasty. *Clin Orthop Relat Res* 2002; (**401**): 230-238 [PMID: 12151900 DOI:10.1097/00003086-200208000-00026]

No volume or issue

9 Outreach: Bringing HIV-positive individuals into care. *HRSA Careaction* 2002; 1-6 [PMID: 12154804]

Books

Personal author(s)

10 **Sherlock S**, Dooley J. Diseases of the liver and billiary system. 9th ed. Oxford: Blackwell Sci Pub, 1993: 258-296

Chapter in a book (list all authors)

11 **Lam SK**. Academic investigator's perspectives of medical treatment for peptic ulcer. In: Swabb EA, Azabo S. Ulcer disease: investigation and basis for therapy. New York: Marcel Dekker, 1991: 431-450

Author(s) and editor(s)

12 **Breedlove GK**, Schorfheide AM. Adolescent pregnancy. 2nd ed. Wieczorek RR, editor. White Plains (NY): March of Dimes Education Services, 2001: 20-34

Conference proceedings

13 **Harnden P**, Joffe JK, Jones WG, editors. Germ cell tumours V. Proceedings of the 5th Germ cell tumours Conference; 2001 Sep 13-15; Leeds, UK. New York: Springer, 2002: 30-56

Conference paper

14 **Christensen S**, Oppacher F. An analysis of Koza's computational effort statistic for genetic programming. In: Foster JA, Lutton E, Miller J, Ryan C, Tettamanzi AG, editors. Genetic programming. EuroGP 2002: Proceedings of the 5th European Conference on Genetic Programming; 2002 Apr 3-5; Kinsdale, Ireland. Berlin: Springer, 2002: 182-191

Electronic journal (list all authors)

15 Morse SS. Factors in the emergence of infectious diseases. Emerg Infect Dis serial online, 1995-01-03, cited 1996-06-05; 1(1): 24 screens. Available from: URL: http://www.cdc.gov/ncidod/eid/index.htm

Patent (list all authors)

16 **Pagedas AC**, inventor; Ancel Surgical R&D Inc., assignee. Flexible endoscopic grasping and cutting device and positioning tool assembly. United States patent US 20020103498. 2002 Aug 1

Statistical data

Write as mean ± SD or mean ± SE.

Statistical expression

Express *t* test as *t* (in italics), *F* test as *F* (in italics), chi square test as χ^2 (in Greek), related coefficient as *r* (in italics), degree of freedom as υ (in Greek), sample number as *n* (in italics), and probability as *P* (in italics).

Units

Use SI units. For example: body mass, m (B) = 78 kg; blood pres-

sure, p (B) = 16.2/12.3 kPa; incubation time, t (incubation) = 96 h, blood glucose concentration, c (glucose) 6.4 ± 2.1 mmol/L; blood CEA mass concentration, p (CEA) = 8.6 24.5 μg/L; CO_2 volume fraction, 50 mL/L CO_2, not 5% CO_2; likewise for 40 g/L formaldehyde, not 10% formalin; and mass fraction, 8 ng/g, *etc*. Arabic numerals such as 23, 243, 641 should be read 23 243 641.

The format for how to accurately write common units and quantums can be found at: http://www.wjgnet.com/2218-5836/g_info_20100724204625.htm.

Abbreviations

Standard abbreviations should be defined in the abstract and on first mention in the text. In general, terms should not be abbreviated unless they are used repeatedly and the abbreviation is helpful to the reader. Permissible abbreviations are listed in Units, Symbols and Abbreviations: A Guide for Biological and Medical Editors and Authors (Ed. Baron DN, 1988) published by The Royal Society of Medicine, London. Certain commonly used abbreviations, such as DNA, RNA, HIV, LD50, PCR, HBV, ECG, WBC, RBC, CT, ESR, CSF, IgG, ELISA, PBS, ATP, EDTA, mAb, can be used directly without further explanation.

Italics

Quantities: *t* time or temperature, *c* concentration, *A* area, *l* length, *m* mass, *V* volume.
Genotypes: *gyrA*, *arg* 1, *c myc*, *c fos*, *etc*.
Restriction enzymes: *Eco*RI, *Hin*dI, *Bam*HI, *Kbo* I, *Kpn* I, *etc*.
Biology: *H. pylori*, *E coli*, *etc*.

Examples for paper writing

Editorial: http://www.wjgnet.com/2218-5836/g_info_20100723140942.htm

Frontier: http://www.wjgnet.com/2218-5836/g_info_20100723141035.htm

Topic highlight: http://www.wjgnet.com/2218-5836/g_info_20100723141239.htm

Observation: http://www.wjgnet.com/2218-5836/g_info_20100723141532.htm

Guidelines for basic research: http://www.wjgnet.com/2218-5836/g_info_20100723142040.htm

Guidelines for clinical practice: http://www.wjgnet.com/2218-5836/g_info_20100723142248.htm

Review: http://www.wjgnet.com/2218-5836/g_info_20100723145519.htm

Original articles: http://www.wjgnet.com/2218-5836/g_info_20100723145856.htm

Brief articles: http://www.wjgnet.com/2218-5836/g_info_20100723150253.htm

Case report: http://www.wjgnet.com/2218-5836/g_info_20100723150420.htm

Letters to the editor: http://www.wjgnet.com/2218-5836/g_info_20100723150642.htm

Book reviews: http://www.wjgnet.com/2218-5836/g_info_20100723150839.htm

Guidelines: http://www.wjgnet.com/2218-5836/g_info_20100723150924.htm

SUBMISSION OF THE REVISED MANUSCRIPTS AFTER ACCEPTED

Please revise your article according to the revision policies of *WJCO*. The revised version including manuscript and high-resolution image figures (if any) should be re-submitted online (http://www.wjgnet.com/2218-4333office/). The author should send the copyright transfer letter, responses to the reviewers, English language Grade B certificate (for non-native speakers of English) and final manuscript checklist to wjo@wjgnet.com.

Language evaluation

The language of a manuscript will be graded before it is sent for revision. (1) Grade A: priority publishing; (2) Grade B: minor language polishing; (3) Grade C: a great deal of language polishing needed; and (4) Grade D: rejected. Revised articles should reach Grade A or B.

Copyright assignment form

Please download a Copyright assignment form from http://www.wjgnet.com/2218-5836/g_info_20100724204516.htm.

Responses to reviewers

Please revise your article according to the comments/suggestions provided by the reviewers. The format for responses to the reviewers' comments can be found at: http://www.wjgnet.com/2218-5836/g_info_20100724204306.htm.

Proof of financial support

For paper supported by a foundation, authors should provide a copy of the document and serial number of the foundation.

Links to documents related to the manuscript

WJO will be initiating a platform to promote dynamic interactions between the editors, peer reviewers, readers and authors. After a manuscript is published online, links to the PDF version of the submitted manuscript, the peer-reviewers' report and the revised manuscript will be put on-line. Readers can make comments on the peer reviewer's report, authors' responses to peer reviewers, and the revised manuscript. We hope that authors will benefit from this feedback and be able to revise the manuscript accordingly in a timely manner.

Science news releases

Authors of accepted manuscripts are suggested to write a science news item to promote their articles. The news will be released rapidly at EurekAlert/AAAS (http://www.eurekalert.org). The title for news items should be less than 90 characters; the summary should be less than 75 words; and main body less than 500 words. Science news items should be lawful, ethical, and strictly based on your original content with an attractive title and interesting pictures.

Publication fee

WJO is an international, peer-reviewed, Open-Access, online journal. Articles published by this journal are distributed under the terms of the Creative Commons Attribution Non-commercial License, which permits use, distribution, and reproduction in any medium, provided the original work is properly cited, the use is non commercial and is otherwise in compliance with the license. Authors of accepted articles must pay a publication fee. The related standards are as follows. Publication fee: 1300 USD per article. Editorial, topic highlights, original articles, book reviews and letters to the editor are published free of charge.