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MJM

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NOTICE TO CONTRIBUTORS

The *Medical Journal of Malaysia* welcomes articles of interest on all aspects of medicine in the form of original papers, research notes, communications and correspondence. The MJM also welcomes brief abstracts, of not more than 50 words, of original papers published elsewhere, concerning medicine in Malaysia. Articles are accepted for publication on condition that they are contributed solely to *The Medical Journal of Malaysia*. Neither the Editorial Board nor the Publishers accept responsibility for the views and statements of authors expressed in their contributions. The Editorial Board further reserves the right to reject papers read before a society. To avoid delays in publication, authors are advised to adhere closely to the instructions given below.

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Summary and Key Words: A summary of not more than 100 words should be provided immediately after the title page. Below the summary, provide and identify 3 to 10 key words or short phrases that will assist indexers in cross-indexing your article. Use terms from the medical subject headings list from *Index Medicus* where possible.

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Materials and Methods: Describe your selection of the observational or experimental subjects (patients or experimental animals, including controls) clearly, identify the methods, apparatus (manufacturer's name and address in parenthesis), and procedures in sufficient detail to allow other workers to reproduce the results. Give references to established methods, including statistical methods; provide references and brief descriptions of methods that have been published but are not well-known; describe new or substantially modified methods, give reasons for using them and evaluate their limitations.
Identify precisely all drugs and chemicals used, including generic name(s), dosage(s) and route(s) of administration. Do not use patients' names, initials or hospital numbers. Include numbers of observation and the statistical significance of the findings when appropriate.
When appropriate, particularly in the case of clinical trials, state clearly that the experimental design has received the approval of the relevant ethical committee.

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Journals

1. Standard Journal Article
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2. Corporate Author
   The Committee on Enzymes of the Scandinavian Society of Clinical Chemistry and Clinical Physiology. Recommended method for the determination of gammaglutamyltransferase in blood. Scand J Clin Lab Invest 1976;36 : 119 -125

Books and Other Monographs

3. Personal Author(s)
   Osler AG. Complement: mechanisms and functions. Englewood Cliffs: Prentice-Hall, 1976.

4. Corporate Author
   American Medical Association Department of Drugs. AMA drug evaluation (3rd ed.) Littleton: Publishing Sciences Group, 1977.

5. Editor, Compiler, Chairman as Author
   Rhodes AJ, Van Rooyen CE (comps). Textbook of virology: For students and practitioners of medicine and the other health sciences (5th ed). Baltimore: Williams & Wilkins, 1968.

6. Chapter in Book
   Weinstein L, Swartz MN. Pathogenic properties of invading micro-organisms. In: Sodeman WAJr, Sodeman WA (eds). Pathologic physiology: mechanisms of disease. Philadelphia: WB Saunders, 1974: 457 - 72.

7. Agency Publication
   National Care for Health Statistics. Acute conditions: incidence and associated disability, United States, July1968 - June 1969. Rockville, Me: National Centre for Health Statistics, 1972. (Vital and health statistics). Series 10: data from the National Health Survey, No 69). (DHEW Publication No (HSM) 72 - 1036).

Other Articles

8. Newspaper Article
   Shaffer RA. Advances in chemistry are starting to unlock mysteries of the brain: discoveries could help cure alcoholism and insomnia, explain mental illness. However, the messengers work. Wall Street Journal 1977; Aug 12: 1(col 1), 10 (col 1).

9. Magazine Article
   Roucehe B. Annals of medicine: the Santa Claus culture. The New Yorker 1971; Sep 4: 66 - 81).

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LECTURE

To Talk of Many Things

10th MOA Lecture: 24 May 2002

A K Abdul Hamid

MBBS, FRCSEd., MChOrth., FAMM

"The time has come," the walrus said,
"To talk of many things;
Of shoes --and ships -- and sealing wax --
Of cabbages -- and kings --
And why the sea is boiling hot --
And whether pigs have wings."

--Lewis Carrol: *The Walrus and the Carpenter* in "Alice in Wonderland".

An aura of pride, honour and a sentiment of fraternity swirl around me as I stand before this august gathering of our esteemed Association, in the presence of some of my close overseas friends, to deliver the 10th MOA Lecture. I thank the President and Council of the Association for having given me this privilege.

The Malaysian Orthopaedic Association has an interesting history. It was actually founded in 1967, in the Department of Orthopaedic Surgery, University of Malaya, with Tan Sri Dato' Dr Abdul Majid Ismail its founder President. However in 1979, the Association was de-registered for failing to submit annual reports and accounts over a few years. In 1980 when Dato' Dr Mahmood Merican was the President and I was the Honorary General Secretary, a new Constitution was drawn up and submitted, and the Association was formally registered again. The late Dr Jimmy Khaw Joo Hua, who had some knowledge on heraldry, was responsible for drawing the emblem of the Association. It was intended to have the figure "1967" in the multi-pointed yellow star in the emblem, but the Registrar would not permit it, and so the star remains empty.

Healthcare Reform

Medicine has been, and is continually, going through changes and reforms since the birth of our profession. The influence of science and technology, the recognition of diseases like AIDS and Alzheimer, the advent of new drugs to combat cancer, infections, and heart and degenerative diseases, the development of genetic engineering and biotechnology to control diseases, research into cloning, and so on, have opened out new vistas into our understanding of diseases and how patients may benefit from new knowledge available to us.

A significant upheaval is also on healthcare reforms. The practice of medicine is increasingly being measured in terms of how it affects health care reforms. What is reform? In general, any reform must aim to reconstruct an existing structure or system in order to enable it to achieve its original end (s) in an improved way[1].

The health economist is concerned that health care expenditure has increased over the past two decades by an average of 11.6% per year, considerably higher than the overall rate of inflation of 8.7%[2].

Individual consumers are not the only ones affected by escalating health care costs. Increased government outlays through federal health care provision and assistance exacerbate the national health deficit. The Ford Motor Company is believed to spend much more on health care than it does on steel. As more of our money goes into

health care, less is available for other critical social needs, such as education and economic investment. Of course, in some countries, the budget allocation for defence far outweighs that for health care.

The government has been concerned about escalating health care cost in our country and is seeking solutions. Among the steps taken include the establishment and functioning of Third Party Administrators (or Managed Care Organisations, MCOs) to reduce the high healthcare expenditure of the corporate sector by controlling providers; it has corporatised IJN and university hospitals and it has privatized a number of health care related services.

The government is planning to establish is a single-payer system of national healthcare financing, covering all citizens equally, administered by the government and financed through taxation of citizens, based on income and payroll, and subsidised from central federal funding. Private insurance and out-of-pocket payments would be possible for citizens seeking treatment in private health care facilities. This broad theme has been mulled by the government for the past 20 years. There are indications that it may be implemented within the next few years, with the proviso that numerous healthcare infrastructural changes, besides collection and management of funds, are in position first.

Built into this scheme is also an attempt to alter behaviour of the individual with regards his own health care, and make him responsible for his wellness. The importance of prevention of disease and prophylaxis will be emphasized. The system will also introduce disease-specific basic packaging (Diagnosis Related Group or case mix) to cap and control the doctor's professional fees and the hospital charges for treatment of particular diseases. This reform will inevitably include both the public and private sectors in an integrated scheme.

Inevitably, too, the behaviour of the doctor will also be expected to change. The current trends in our management of orthopaedic patients will be modified or curtailed by this health care reform: a limitation to open-market choice of implants and prostheses, control of professional fees, control of provision of orthoses and aids, justification for surgery, limitation of hospital stay of patients, and so on.

This changing scenario will impose on us a challenge to preservation of excellence in our practice and ethical care of our patients. In our acceptance and adaptation to this new order, altruism and a humane approach will need to be bolstered to contribute constructively and uphold the quality of our service to the patients. Patients should not suffer because of any personal unhappiness or frustrations or any such emotional overtones felt by doctors in their reaction to these changes.

Outcome Research

Outcome research refers to a very specific kind of study. It is a branch of clinical research that is broadening the definitions of the valid indicators of health. Outcome research is notable for its emphasis on patients' satisfaction with the outcomes of care and for its inclusion of their subjective perception of how the quality of life is affected by the medical care they receive[3].

The basic premise of outcome research is that when recommending treatment, doctors need to be aware of the likely outcomes of different treatments and what matters to individual patients. Only systematic research can provide this information, and patient preference is crucial.

Outcome research initiatives will reinforce the need for all of us to shift the focus of our clinical outcome studies from procedural and technical concerns to the actual health outcomes obtained

by our patients. We will be required to report the benefit that the procedure or technique has on the health and functional status of the patients on whom it was performed as well as the cost of the benefit in terms of both complications and dollars.

Outcomes can be compared between providers and used to identify best practice and to develop practice guidelines. It can form the basis for remedial action when adverse treatment results occur in a clinical department, as in the Bristol paediatric cardiac surgery disaster, where out of 53 operations performed by two surgeons between 1988 and 1995, 29 children died and 4 had some form of brain damage.

A study auditing the outcome of total knee replacement at the Freeman Hospital in Newcastle-upon-Tyne tested out the Nottingham Health Profile, a well tested generic scale. The data that emerged have prompted questions over practice. For example, the observation that patients with rheumatoid arthritis show as great a benefit as those with osteoarthritis has implications of patient selection. There is concern over why bilateral knee replacements seem worse at three months than unilateral replacements and whether it would be better to spread the two procedures[4].

Before long we will be expected to describe the health status of our orthopaedic patients in terms of how well the orthopaedic solution selected for the presenting musculo-skeletal problem improved the ability of the patients to function, perform, and behave. Health status measurements that can be expected to become part of the designs of orthopaedic outcomes studies include the physical or orthopaedic function in life and the patient's perception of their own sense of well-being.

As quality care is evaluated and refined, the concept of the patient's outcomes emerges repeatedly. Both payers and clinicians are beginning to adopt a posture that gives greater emphasis to the patients' assessment of quality and outcome.

Orthopaedic surgeons must take time to look up from their operating tables and *understand* the importance of outcome research. Perhaps the Malaysian Orthopaedic Association can take a lead role in our country to initiate outcome research on common orthopaedic operations.

Advances in Orthopaedics

The advance in orthopaedic practices in the past four decades is too little on skill and too much on technology. Research funding is channeled more into a stronger and more lasting metal implant, a more versatile surgical instrument, or a finer endoscope, than into developing skill or teaching a finer or refined cognitive surgical technique. This has contributed to so-called "glamour orthopaedics."

Orthopaedics is big business. It is not difficult to conjure up an image of an orthopaedic surgeon - one who charges high fees, runs a high volume practice, operates on almost everyone using devices from a company that provides him attractive incentives, uses great magnetism when unbundling his professional fees, and is surrounded by an excess of material goods while returning precious little time or money to the community.

Orthopaedic surgeons have increasingly developed a passionate romance with surgery, particularly in trauma management, acting on the premise that if it moves, fix it.

Graham Apley (1992) in an editorial entitled "Fixation is Fun," lamented that surgeons who are justifiably proud of their operative technique and take pleasure in teaching it sometimes set a bad

example by relegating non-operative methods to uninstructed juniors. "It is not enough to train surgeons to be expert metal workers; they need to master all the available techniques of treatment, and then develop the wisdom to choose between them" [5].

The arthroscopy mills, the total joint replacement mills, the fracture mills, the spinal instrumentation mills, conducted or managed by orthopaedic surgeons, all lend themselves to high technology. Many of the courses offered in orthopaedics these days deal with how-to-perform procedures with some new technological innovation. Little emphasis is placed on the basic biological process.

Henry Mankin once said: "Future changes in orthopaedics will be based in biology and more specifically in our ability to understand and alter its basic unit, the cell." We have seen the truth in this statement with current research at sub-cellular level providing information on diseases which can be prevented by genetic engineering.

Modern medicine has changed human values and is believed to be inherently contradictory between Science and humanity, technology and compassion. Einstein felt that this was an extremely dangerous stance to assume. He said: "the concerns for man and his destiny must always be the chief interest of all technical effort" [6].

Some believe that the striking current technical advances may prove to be blind side-shoots of surgical evolution. There has to be a limit to perfection in design and material. Perhaps we should momentarily pause to ruminate on an extreme view statement by Philip Wiles (1952): "However important surgery may be now, it should be the aim of all doctors, including surgeons, to limit and ultimately abolish it." Perhaps this, in some tangential manner, emphasizes on the need to reform human behaviour to prevent all forms of disease and disability.

Orthopaedic surgery has the manpower, the intelligence, and the innovation to carry the specialty beyond technology for the benefits of our patients and society. Do orthopaedic surgeons have the will and the desire?

It is said that because orthopaedic surgery has become so mechanical, patients have come to be considered mere mechanisms. Technological advances have led to the traditional relationship between doctors and patients being compromised to some extent, and have placed barriers of one sort or another between the patient and the doctor. We are now able to diagnose patients' illnesses with less and less personal contact, relying more on laboratory tests, X-rays, computed tomography, MRI scans and so on. This has led to the doctor to become increasingly impersonal and at the same time not develop the ability to detect the fine sensations of disease - the feel, the appearance, the smell. I recall how Professor Gordon Ransome in our medical school in Singapore could, on stepping into the ward, pick out by smell a patient with pulmonary TB.

The increasing trend to rely on more sophisticated diagnostic tools in clinical practice without the benefit of simple basic investigations, besides not helping to develop the intellectual and professional skills of the doctor, also escalates the cost of health care generally. It has compelled corporate bodies to impose conditions of prior approval before their employees are subjected to such expensive tests, a procedure which is interpreted to encroach on the professional autonomy of medical practitioners. However, one cannot deny that such and many other external impositions have come about because of our profession's failure to self regulate.

Although MRI and CT scan have their special place in diagnostic imaging, plain radiography

may reveal more details pertaining to joint disease. Facet joint degeneration, rotational deformities of the spine, extent of syndesmophytosis are better visualized in plain X-rays, as are weight bearing joint space narrowing, early signs of degeneration and subchondral sclerosis, loose bodies, and so on.

We know too that the details sometimes apparent on MRI and CT scan are quite unrelated (and probably irrelevant) to the physician's clinical impressions of patient's presenting complaints, and may be a cause for consternation and alarm to the patients when they see arrows and circles entered by the radiologist on the films. Many needless arthroscopy will be performed if every MRI is taken at face value[7].

In a now well-known study in the USA, MRI of the cervical spine carried out on normal medical undergraduates, without any symptoms or complaints related to the neck, revealed clinically irrelevant abnormalities in a large majority of the subjects.

The alarming frequency with which the spine is operated upon in private hospitals, based more on MRI findings than on absolute clinical indications, is a matter of concern and has been adequately addressed in a previous MOA lecture. It well to remember, and it cannot be more stressed, that the purpose of ordering an MRI scan should be to ***avoid*** an unnecessary operation.

Arthroscopy

We are witness since the 70's to the explosive manner in which technical expertise has continued to revolutionise and miniaturise intra-articular surgery, including reconstruction of cruciate ligaments, repair of peripheral meniscal tears, and endoscopic carpal tunnel release, and so on.

We have observed chondromalacia of the retropatellar surface very commonly even in patients without retropatellar symptoms and signs when performing diagnostic arthroscopy. Leslie and Bentley (1977) showed that only half of those reporting symptoms of chondromalacia patellae were found to have the condition at arthroscopy [8].

Arthroscopic examination of the knee for chondromalacia patellae is probably of little value and arthroscopic shaving which is being done frequently, makes little difference. I used to perform shaving of the retropatellar surface for chondromalacia in the early days, with doubtful result, and would agree with Noble who stated that "shaving is at its most effective on the chin and not in the knee" [9].

Jonathan Noble in an editorial in JBJS in 1992 commented: "There is an increasing trend in certain minds that any pain from mid-thigh to mid-calf should be investigated by knee arthroscopy" [9].

This is carried out often without the benefit of plain radiography of the knee. It is a fact derived from experience that a badly performed arthroscopy is worse than a well performed arthrotomy on the knee for partial meniscectomy or any other intra-articular procedure. It is worthwhile, in these days of cost-effectiveness, to enquire how many arthroscopies are clinically essential pre-operatively and have been beneficial to the patient post-operatively. Perhaps an outcome study would be quite illuminating.

Articular Cartilage

I have never been failed to be fascinated by the flawless texture and structural perfection of the articular cartilage when I view it through the arthroscope and more so when seeing it in arthrotomy of the knee. The only word I use to describe it in my operation notes when I find it

devoid of any damage is "pristine" which conjures in my mind the connotations of "original and pure".

Attempts to culture articular cartilage from chondrocytes have not been completely fruitful, though research in this field has been conducted by Mankin, Bentley and others. Many techniques have been developed to re-surface articular cartilage, and most of us have felt the impotence with which we view total articular loss lesions on the femoral condyle in young or middle aged patients. We have tried drilling and abrading as process of chondroplasty, but the results have been unpredictable and unsatisfactory. Mosaic chondroplasty is now reported to be giving encouraging results. The recent development of in-vitro culture of articular cartilage using chondrocytes harvested by special technique from the same patient and grafting it into the defects with periosteal scaffolding after 3-4 weeks, promises to be an exciting solution for a difficult problem. Obviously this is an area that needs to be researched more.

Peripheral Nerve Surgery[10]

Though digital nerve anastomosis is invariably successful, my experience with mixed nerve repair in the arm or forearm has left me frustrated, as such surgery has often yielded unfavourable results. Indeed, for centuries surgeons have been uncomfortable with lesions of peripheral nerves, and the way to manage nerve transection. In the late 19th century, the first attempt to suture nerves using the connective tissue of the nerve was made by Hueter (1873). These were not successful. Langley & Hashimoto in 1917 demonstrated individual fascicular repair with tight suture of perineurium. Jack Tupper in 1977 coapted each fascicle of a polyfascicular nerve individually by microsurgery.

The problem with aberration of axon sprouts and ingrowth of connective tissue, at the suture site with less than successful outcome led to tubulisation at the site of repair by many surgeons.

Millesi (1980) suggested that coaptation has to be performed by microsurgery according to the fascicular pattern. However, sensory and motor fibre identification is not easy even with histochemical staining techniques [10].

In 1951 Levi Montalcini and Hamburger discovered nerve growth factor, the first of many factors influencing nerve regeneration, also used in brachial plexus traction injuries.

In 1979 Lundborg and Hansson showed that if a free space was provided between two nerve stumps, the nerve fibres were able to find their way to the distal stump. The question was whether the growth in the space was really regenerated nerve tissue or merely a neuroma growing along the free space. More recently biodegradable conduits are being offered to provide space for nerve regeneration without coaptation. The research will have to continue to find solutions for another area of extreme difficulty in orthopaedics.

While the technical search to perfect nerve repair goes on, for the clinician the major problem of failed nerve repair is intractable pain at the anastomotic site due to axon sprouts. Motor paralysis, sensory loss and sympathetic nerve denervation, particularly in the upper limb produce a morbidly depressed, miserable patient with agonizing pain not responding to the usual treatment procedures. Such a patient with ulnar nerve injury at the elbow, I recall, had pleaded for amputation of his hand when I was working with Campbell Semple in Glasgow in 1977.

Leadership in Orthopaedics

Leadership has many definitions; one which I find succinct is "it is the ability to get work done with

one through others, while at the same time winning their confidence, respect, loyalty and willing cooperation". It seems the most appropriate qualification for leadership in the medical profession in general, and more specifically in orthopaedic practice.

Leadership is action, not position. Leaders influence many aspects of work. They are the chief communicator of the group, affect motivation by their behaviour and are responsible for the group's objectives being understood and achieved. Leadership is a critical influence of group performance.

What are the qualities of a leader? Intelligence with possible academic achievement; social maturity, meaning emotional maturity and wide range of interests; self-motivation and an achievement orientation; self confidence and good communication skills are some basic ingredients.

Certain attributes make for effective leadership. Gardner in "On Leadership" [11] suggested that the attributes of leadership were:

1. *Physical vitality and stamina*
2. *Intelligence and judgment in action*
3. *Eagerness to accept responsibilities*
4. *Task competence*
5. *Understanding of constituents (followers) and their needs*
6. *Capacity to motivate*
7. *Skill in dealing with people*
8. *Courage, resolution, steadiness*
9. *Capacity to win and hold trust*
10. *Adaptability, flexibility*

Leadership in Orthopaedics presents many facets. Accepting that the leader in a clinical department is the supreme head, then those within that department, entrusted with certain responsibilities, are also leaders in their own rights. Broadly speaking, all orthopaedic surgeons are leaders in their fields, having submitted themselves successfully to the rigors of education, training, examinations, and reaching the point at which many clinical decisions are made daily, with far reaching implications for the patient. All orthopaedic surgeons have the potential to become dynamic leaders in our profession and in the academic and social circles.

Let us view our role in orthopaedic leadership.

Visitors to our country are often amazed at the variety of clinical material available in our public hospitals. With the number of trauma cases lying in our orthopaedic wards, one can be forgiven for thinking that there is a perpetual war going on in the country, if we can indeed view our roads, our factories, construction sites and some of our immigrant labour locations as battle grounds.

The vast majority of our people who cannot afford private health care, not having savings and not having adequate insurance cover, rely exclusively on the public hospitals when they need medical attention.

The management of such patients, the level of care, their speedy return to their family and to their work, need extra consideration and effort. Unfortunately certain uneasy situations prevail. It is common knowledge that operations are frequently cancelled at short notice, patients requiring early surgery remain on the waiting list for days, decisions to operate are reversed after being on the waiting list for many days, or patients are sent home to be recalled later for surgery.

The reasons given are many: inadequate operating hours, shortage of senior doctor with surgical experience, consultant away attending meetings, implant shortage, planned operation list unable to be completed, cancelled by anaesthetist because of cough, and so on. Considering that the cost per day per bed in a public hospital is

close to RM600, considering that patients are unable to return early to their employment, with economic loss to the individual and the country, considering that the patient and his family are in agony and frustration, these reasons need evaluation and appropriate remedial action by our orthopaedic leaders.

MacAusland, in his Presidential address to members of the American Orthopaedic Association in 1980 said:

"I will never forget a memorial to the first doctor on the island of Jamaica. This plaque contained the following words written by an unknown author:

'When the physician bears the patient's pain, then will medicine our fainting hope sustain'" [12].

The quality of some of the articles submitted for publication in our local medical journals leaves much to be desired. Leaders in institutions need to study all papers prepared by their junior colleagues and give advice and guidance on their improvement before final submission, for the standard and quality of these papers reflect on the image and leadership in the departments in which these doctors work.

While teaching institutions produce a fair number of research papers, the number from public hospitals is low. Heavy workload is often blamed. Orthopaedic leaders should take the initiative to provide the time, guidance and motivation for junior doctors to indulge in research and produce papers for publication. One of the entry requirements for membership into the Academy of Medicine Malaysia is at least one original scientific publication in an indexed journal, and many senior specialists cannot satisfy even this basic requirement. This has to be an example of leadership failing to lead by example.

Leaders need to be role models for their junior doctors, by being approachable, listening to their problems, willing to teach and guide, setting examples of ethical practice, demonstrating trade proficiency and communication skills, demonstrating the ability to tackle clinical problems with competence and confidence, by being up to date in their professional knowledge and skills, and showing an interest in their career progress.

The teaching of medical ethics and the constant reinforcement of its principles as part of the training of housemen, medical officers and trainee specialists is a duty of the clinical leader which needs to be emphasized. The importance of self regulation and ethical practice by our profession must be constantly impressed upon our younger doctors so that these qualities will get firmly ingrained in them as they in turn mature into leaders in their own rights.

The challenge in leadership development is for leaders to help bring younger leaders along. An environment must be created to provide a favourable climate of expectation and opportunity. Mentoring is essential. One must pause to think of the potential for mentoring if each one of us deliberately and carefully began to develop leadership qualities in a younger colleague or colleagues.

I have indeed **talked of many things**. Perhaps a definition of Orthopaedics suggested by McCollister Evarts, at the Shands Lecture, will capture most of the sentiments which I have expressed.

"Orthopaedics is a broad medical interdisciplinary specialty encompassing the recognition, investigation, and management of the diseases and disorders of the musculo-skeletal system. Its educational, research, patient-care and service commitments are extensive and balanced, as witnessed by its broad educational requirements;

dedicated teachers, practitioners, and researchers; the quest for the highest standards of quality of care, and the maintenance of continuing competence" [13].

Conclusion

In planning for this talk, I have chosen a few topics which I had hoped would be stimulating and a little philosophical, and also which would highlight the need for research by orthopaedic surgeons in our country in some challenging clinical areas.

I find no better way to close my lecture than by reminding ourselves of the Prayers of a Physician by Sir Robert Hutchinson (in Modern Treatment, 1953).

From inability to let well alone:
From too much zeal for the new and
contempt for what is old;
From putting knowledge before wisdom,
science before art, and cleverness
before common sense;
From treating patients as cases, and
from making the cure of the disease
more grievous than the endurance
of the same,
Good lord, deliver us.

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ORIGINAL ARTICLE

The Sagittal Spinal Profile in Normal Malaysian Males

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Summary

The objective of this study is to document the sagittal spinal profile of normal Malaysian males. One hundred and one normal medical students were recruited for the study, from which 73 had complete sets of data. The sagittal spinal profile was measured via non-contact Video Raster Stereography (VRS) v 2.0 software and Formetric Instrument System. The relationship between the sagittal profile to ethnicity and age were also studied. Data was analysed with ANOVA, simple linear regression and Pearson's Correlation; with $p< 0.05$ set for significance. The thoracic kyphosis ranges from 28.14 to 40.02 degrees, lumbar lordosis ranges from 18.22 to 29.74 degrees; and sacral inclination ranges from 15.66 to 26.34 degrees. Thoracic kyphosis ($r=0.353$, $p=0.002$), lumbar lordosis ($r=0.285$, $p=0.014$); and sacral inclination ($r=0.252$, $p=0.031$) are increased with age, but not with ethnic group. In addition, thoracic kyphosis and lumbar lordosis ($r=0.841$, $p=0.001$), lumbar lordosis and sacral inclination ($r=0.897$, $p=0.001$); thoracic kyphosis and sacral inclination ($r=0.793$ $p=0.002$) are positively correlated. We conclude that the sagittal spinal profile in normal Malaysian males increases with age, demonstrates reciprocity, but no relationship to ethnicity is seen.

Key Words: Sagittal spine, Males, Malaysia

Introduction

Despite the fact that knowledge of the normal sagittal spinal profile is increasingly important in the practice of spinal surgery to day; only a few extensive studies exist in Arab[1], US[2], Taiwanese[3] and Greek[4] populations reporting the sagittal spinal profile via radiographic analysis. It is not surprising, therefore, normal sagittal spinal alignment remains not as clear as the better-defined alignment in coronal and transverse planes. To a large extent, this lack of information can be explained by difficulties in obtaining accurate serial measurements of normal subjects, since screening of normal healthy subjects by radiography is expensive, harmful and unethical. In addition, the radiographic technique does not provide sufficient information on the complex shape of the spine and involves subjective measurements on two films; the antero-posterior view and the lateral view. To bridge the gap in our knowledge regarding the sagittal spinal alignment in Malaysian subjects, this current study

was done using a computer-instrument assisted technique, which does not use radiation, is non-invasive, non-contact, raster 3-D measurement of the spine to measure the sagittal spinal profile in asymptomatic pre-clinical male medical students of UPM (we could not get female volunteers).

Materials and Methods

One hundred and one male pre-clinical undergraduate medical students were recruited for this study (we could not get female subjects as there were no female volunteers). A self-administered screening proforma to exclude back pain and spinal disease was employed, after which a back examination was carried out. Written consent was obtained from the respondents who passed both screens, to proceed further.

Measurement of Sagittal Spinal Profile
To measure the standing sagittal spinal profile of asymptomatic subjects in this study, a non-invasive computer-instrument-assisted technique was used. This technique involved the combination of computer software; the Video Raster Stereography (VRS) Version 2.0 Software, and a measuring system, known as Formetric Instrument System. This technique allows non-contact 3-D measurement of the sagittal spinal profile as well as geometric analysis of the human back. This technique is chosen because it has the advantage of being a non-invasive sagittal spinal profile evaluation and avoids unnecessary exposure of asymptomatic subjects to radiation. The computer-instrument-assisted technique contains the following major subassemblies

Measuring System: The measuring system contains a raster projector, which illuminates the surface of the back, and a video camera, which captures the 3-D image of the back surface. The projector and the camera are firmly aligned parallel to each other.

A Standing Balance Platform with footprint mat: This structure is placed at a distance of 2 meters from the measuring system. Both the measuring system and the platform should be aligned parallel to each other on a flat and hard surface at the same horizontal level. The platform is where the subject stands on. It is to determine the weight difference between the right and left halves of the trunk.

A Black Background Screen: This 2-meter length black background screen is placed immediately in front of the standing balance platform. The black background screen functions to reduce adverse light condition and also acts as the reference field view of the video camera for image aquisation.

The Computer and VRS version 2.0 software: The computer consists of a standard PC for image processing, a printed circuit board for image acquisition, a module for rotation of live images and image presentation on a monitor.

The Laser Printer: The results of shape analysis are plotted on the laser printer as graphic protocols.

The subjects were asked to undress to expose their backs from the level of vertebrae prominence up to the level of coccyx. They were then asked to stand on the standing balance platform with their feet placing on the footprint mat; their hands resting on a handle and their back surfaces facing the raster projector lamp and the video camera. The balance platform would detect any weight difference between the right and left halves of the trunk, and compensate by raising or lowering either foot if needed. After positioning the subject on the standing balance platform, the image acquisition program captures the image. First, the raster projector lamp was switched on to illuminate the surface of the back of the subject. Some degree of postural control was necessary because postural variations may affect the detection of several important

anatomical landmarks, which was needed for the software to calculate the kyphotic and lordotic angles. The subjects were asked to take a deep breath and to hold it; while the 3-D image of the back surface was captured by the video camera. This image was stored in the hard disc, and the image clipping process was carried out. Further image analysis, including the determination of thoracic kyphotic angle, lumbar lordotic angle and sacral inclination angle, were calculated via a specific mathematical model formulated specifically for this program.

Data was analysed with ANOVA, simple linear regression and Pearson's Correlation; with $p < 0.05$ set for significance.

Results

Of the 101 pre-clinical male medical students, 20 students who did not fulfill the selection criteria (chronic backache and mild scoliosis) were excluded from this study. From the remaining 81 students, 73 (90.1%) of them agreed to become the study subjects after obtaining their written consent, whereas 8 (9.9%) opted not to proceed because they did not wish to undress.

The 73 students were classified into ethnic groups; 35 (47.9%) Chinese, 31 (42.5%) Malay and 7 (9.6%) Indian; which represented the composition of the male student population of the pre clinical classes. The age ranged from 19 to 22 years (mean 20.67 years). ANOVA test confirmed the distribution to be random.

Table I: Angle of Thoracic Kyphosis, Lumbar Lordosis and Sacral Inclination

	Thoracic Kyphosis (Degrees)	Lumbar Lordosis (Degrees)	Sacral Inclination (Degrees)
Minimum	28.10	19.21	17.00
Maximum	41.00	30.90	28.50
Mean	34.08	23.98	21.00
Median	34.00	23.60	20.50
Standard Deviation	2.97	2.88	2.67

Table II: The Regression of Thoracic Kyphosis, Lumbar Lordosis and Sacral Inclination on Age

	r	r^2	p-value
Regression of **Thoracic Kyphosis** on Age	0.353	0.125	0.002 (<0.05)
Regression of **Lumbar Lordosis** on Age	0.285	0.081	0.014 (<0.05)
Regression of the **Sacral Inclination** on Age	0.252	0.064	0.031 (<0.05)

The angle of kyphosis, lordosis and sacral inclination (Table I)
The 95% confidence interval for the kyphosis was 28.14 to 40.02 degrees, lumbar lordosis was 18.22 to 29.74 degrees and the sacral inclination was 15.66 to 26.34 degrees.

The sagittal plane and age (Table II)
Even in the short age range of this population (19 to 22 years), there was a significant (but weak direct linear relationship) change in the alignment when referenced to age.

Table III: The difference in sagittal alignment compared with ethnicity

	F-statistic	p-value
Difference in **kyphosis**	0.108	0.898 (> 0.05)
Difference in **lordosis**	1.232	0.298 (>0.05)
Difference in **sacral** inclination	0.977	0.382 (>0.05)

The sagittal alignment and ethnicity (Table III)
There was no observed difference in the sagittal profile with ethnic grouping.

Table IV: The Relationship between kyphosis, lordosis and sacral inclination

	r	p-value
Lumbar lordosis and Sacral inclination	0.897	0.001 (< 0.05)
Thoracic kyphosis and Lumbar lordosis	0.841	0.001 (<0.05)
Thoracic kyphosis and Sacral inclination	0.793	0.002 (<0.05)

The relationship between kyphosis, lordosis and sacral inclination (Table IV)
All the three parameters are integrally linked to each other in a strong direct linear relationship. They demonstrate reciprocity. Each affects the other so as to balance the sagittal spine. For example; if there is an increase in thoracic kyphosis, there is a corresponding increase in lumbar lordosis and sacral inclination, which acts to balance the spine. Lumbar lordosis and sacral inclination showed the strongest relationship.

Table V: Comparison of sagittal profiles

Parameters of sagittal profile (Degree)	This study 2001	Amonoo Kuofi 1992	Ozonoff 1992	Lim RM 1992
Thoracic kyphosis	28.14 - 40.02	NA	21 - 33	NA
Lumbar lordosis	18.22 - 29.74	33 - 54	31 - 50	21.1 - 45.3
Sacral inclination	15.66 - 25.34	34 - 45	NA	16.4 - 36.4

Table VI: Comparison of the parameters of the sagittal profile studies

Parameters of sagittal	This study 2001			Voutsinas 1998			Kovoressis 1998			Vendantam 1998		
	r	cor	p	r	cor	p	r	cor	p	r	cor	p
Thoracic kyphosis and lumbar lordosis	0.841	+	0.001	0.40	+	0.001	NA	+	0.003	NA	+	0.01
Lumbar lordosis and sacral inclination	0.897	+	0.001	0.59	+	0.001	NA	_	0.001	NA	NA	NA
Thoracic kyphosis and sacral inclination	0.793	+	0.02	0.07	+	0.1	NA	_	0.002	NA	NA	NA

Key: r = correlation coefficient
Cor = type of correlation
P = p value
\+ = positive linear correlation
\- = negative linear correlation

Discussion

The sagittal profile we obtained (Table I) is similar to the reported sagittal profiles in the other reports reviewed for this study (Table V). Two distinct differences remain in a comparison between this and any other study; the fact we did not have female subjects, and our measuring system being more objective without inter and intra observer variability. Even so, there was good agreement between all the parameters concerned; with the exception of sacral inclination and lumbar lordosis which have been reported as higher in Arab populations[1]. Although our study had a narrow age range, we did demonstrate that the sagittal profile was influenced by age (Table II). Conflicting data has been published on this, with Amonoo Kuofo[1], Lim RM[3] and Tuzun C[5] reporting the association we see; while Jackson RP[6] and Kovoresis PG[4] reported that lumbar lordosis was not related to age. One postulation is that their subjects may have already lost postural control when measured. Stagnara[7] himself cautioned that proper positioning of the subject is essential to yield reliable, accurate and constantly reproducible measurements. While it was our working assumption that there would be a difference in the sagittal profile and ethnicity, we did not see this (Table III). This could be due to our small sample size. Our present findings on the relationship between the sagittal curves is also reported by Voutsinas[8]. However Kovoressis[4] while agreeing that thoracic kyphosis and lumbar lordosis are positively related, report that sacral inclination is negatively related with both lumbar lordosis and thoracic kyphosis. Vendatam[9] on the other hand, reports a negative relationship between thoracic kyphosis and lumbar lordosis (Table VI).

Conclusion

We conclude that the sagittal spinal profile in normal Malaysian are similar to most reported series; and in increases with age, and demonstrates reciprocity, but no relationship to ethnicity is seen.

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ORIGINAL ARTICLE

The Relationship Between Sagittal Spinal Profile and Body Mass Index in Normal Subjects

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Summary

This study was done to determine the relationship of the sagittal spinal profile in normal subjects to the BMI. One hundred and one normal medical students were recruited for the study, of which 73 had complete sets of data. The BMI was measured using a weighing scale and the height using a meter ruler. The sagittal spinal alignment was measured via non-contact Video Raster Stereography (VRS) v 2.0 software and Formetric Instrument System. Data was analysed with ANOVA and simple linear regression; with $p < 0.05$ set for significance. Of the 73 completed data, 56 were normal (BMI between 18.5 to 24.9kg/m2); 4 overweight, and 13 underweight. None were obese. BMI and thoracic kyphosis had a positive correlation ($p=0.031$) with $r=0.596$; a rise of 1kg/m2 causing an incremental 0.759 degree increase in kyphosis. BMI and lumbar lordosis had a positive correlation ($p=0.002$) with $r=0.729$; a rise of 1kg/m2 causing 0.9 degree increase in lordosis. BMI and sacral inclination had a positive correlation ($p=0.02$) with $r=0.658$; a rise of 1kg/m2 causing 0.753 degree increase in sacral inclination. We conclude that an increase in BMI causes an increase in thoracic kyphosis, lumbar lordosis and sacral inclination.

Key Words: Sagittal spinal alignment, Body Mass Index

Introduction

The association between sagittal spinal profile and BMI has been investigated previously[1,2,3]. While there is agreement that there is a positive correlation between the spinal alignment and BMI; there have been no reports to our knowledge (and from a Medline Search) that have studied the degree of projected change between the two parameters. In addition, no such study with Malaysian data have been published to date. This study was done to determine the relationship of sagittal spinal alignment and BMI, the degree of correlation with each sagittal curve; and the projected change in spinal sagittal alignment with changes in BMI in the Malaysian population.

Materials and Methods

One hundred and one male pre-clinical undergraduate medical students were recruited for this study (we could not get female subjects as there were no female volunteers). A self-administered screening proforma to exclude back pain and spinal disease was employed, after which a back examination was carried out. Written consent was obtained from the respondents who passed both screens, to proceed further.

Measurement of Body Mass Index (BMI)
BMI was calculated based on the weight and height of the subjects. The BMI is weight/height^2; the standard unit being kg/m^2. To measure the weight of the subjects, a digital weighing machine, with an accuracy of $\pm$ 0.2kg, was used. Each time before the weight of the selected respondents is taken, the digital weighing machine was calibrated and the energy level of the battery used in this machine was also examined. The digital weighing machine was placed on a flat and hard surface. Shoes, heavy clothing and garments were removed and a straight standing posture (with shoulders drawn backward and their eyes looking forward at a horizontal level) was adopted to reduce bias in the measurement of weight. To measure the height of the selected respondents, a SECA Bodymeter, with an accuracy of $\pm$ 1mm, was used. The SECA Bodymeter was firmly attached on the wall surface, at a height of two meters from; and parallel to the surface of the ground. The subjects were asked to stand straight with their backs and heels touching the surface of the wall and their soles of feet resting on the flat surface of the ground. The measuring tongue of the Bodymeter was then lowered until the subject's head. The reading shown in the read-off area of the Bodymeter, was carefully recorded to avoid parallax error.

Measurement of Sagittal Spinal Alignment
To measure the standing sagittal spinal profile of asymptomatic subjects in this study, a non-invasive computer-instrument-assisted technique was used. This technique involved the combination of computer software; the Video Raster Stereography (VRS) Version 2.0 Software, and a measuring system, known as Formetric Instrument System. This technique allows non-contact 3-D measurement of the sagittal spinal profile as well as geometric analysis of the human back. This technique is chosen because it has the advantage of being a non-invasive sagittal spinal profile evaluation and avoids unnecessary exposure of asymptomatic subjects to radiation. The computer-instrument-assisted technique contains the following major subassemblies.

Measuring System
The measuring system contains a raster projector, which illuminates the surface of the back, and a video camera, which captures the 3-D image of the back surface. The projector and the camera are firmly aligned parallel to each other.

A Standing Balance Platform with footprint mat
This structure is placed at a distance of 2 meters from the measuring system. Both the measuring system and the platform should be aligned parallel to each other on a flat and hard surface at the same horizontal level. The platform is where the subject stands on. It is to determine the weight difference between the right and left halves of the trunk.

A Black Background Screen
This 2-meter length black background screen is placed immediately in front of the standing balance platform. The black background screen functions to reduce adverse light condition and also acts as the reference field view of the video camera for image aquisation.

The Computer and VRS version 2.0 software
The computer consists of a standard PC for image processing, a printed circuit board for image acquisition, a module for rotation of live images and image presentation on a monitor.

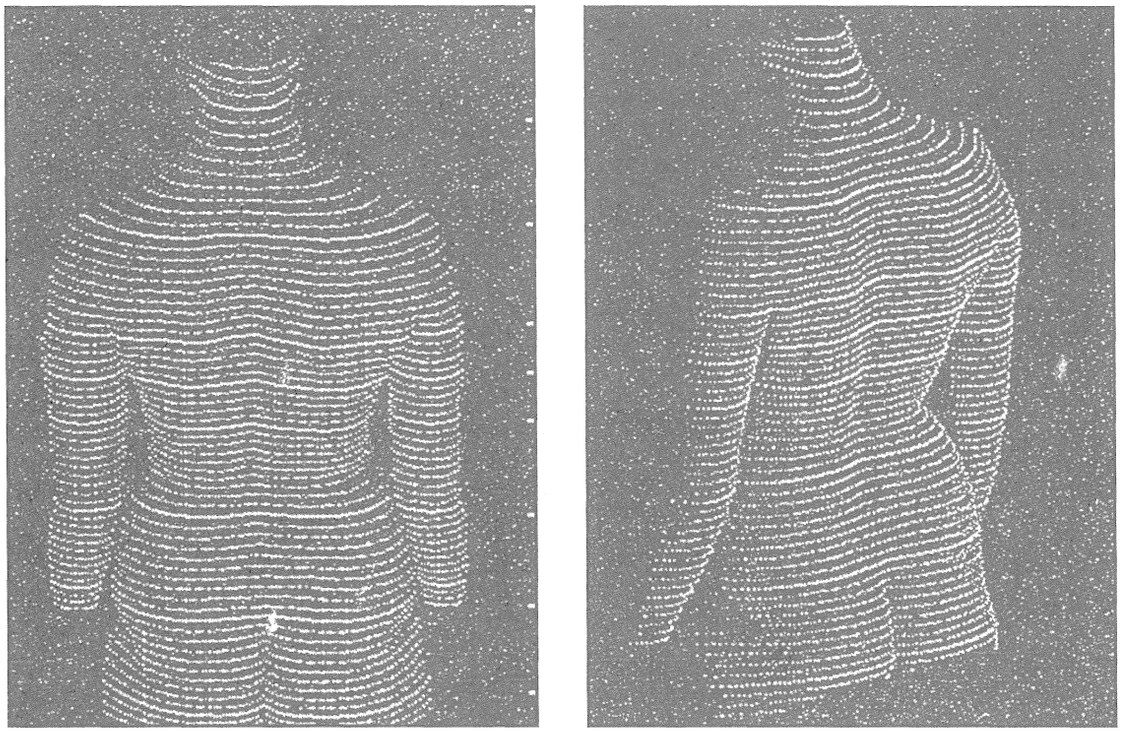

Figure 1: Image of back surface displayed by software

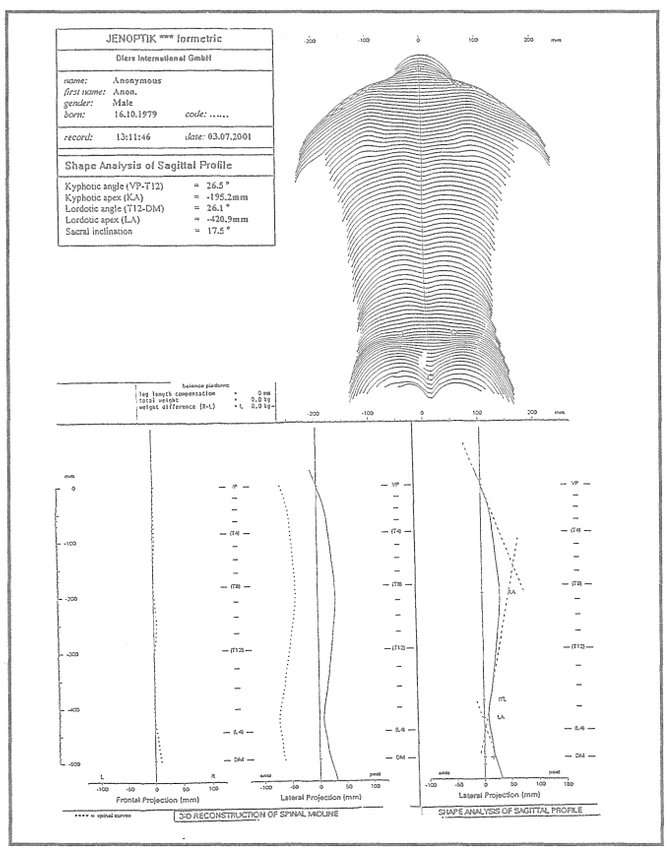

Figure 2: Printed grafic protocols showing results of analysis of back surface

The Laser Printer

The results of shape analysis are plotted on the laser printer as graphic protocols.

The subjects were asked to undress to expose their backs from the level of vertebrae prominence up to the level of coccyx. They were then asked to stand on the standing balance platform with their feet placing on the footprint mat; their hands resting on a handle and their back surfaces facing the raster projector lamp and the video camera. The balance platform would detect any weight difference between the right and left halves of the trunk, and compensate by raising or lowering either foot if needed. After positioning the subject on the standing balance platform, the image acquisition program captures the image. First, the raster projector lamp was switched on to illuminate the surface of the back of the subject. Some degree of postural control was necessary because postural variations may affect the detection of several important anatomical landmarks, which was needed for the

software to calculate the kyphotic and lordotic angles. The subjects were asked to take a deep breath and to hold it; while the 3-D image of the back surface was captured by the video camera. This image was stored in the hard disc, and the image clipping process was carried out (Figure 1). Further image analysis, including the determination of thoracic kyphotic angle, lumbar lordotic angle and sacral inclination angle (Figure 2), were calculated via a specific mathematical model formulated specifically for this program.

Data was analysed with ANOVA and simple linear regression; with $p < 0.05$ set for significance

Table I: Body Mass Index Profile

BMI (kg/m^2)	Ethnic Group			Total
	Malay	Chinese	Indian	
Mean	20.44	21.79	21.29	21.17
Median	20.41	21.32	21.32	20.96
Standard Deviation	2.26	2.33	2.02	
Total Subjects	31	35	7	73

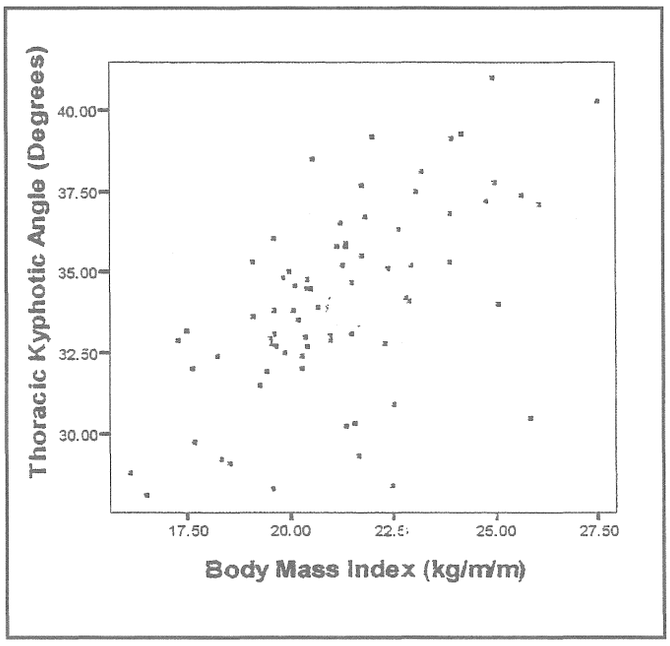

Figure 3: The relationship between thoracic kyphosis and BMI

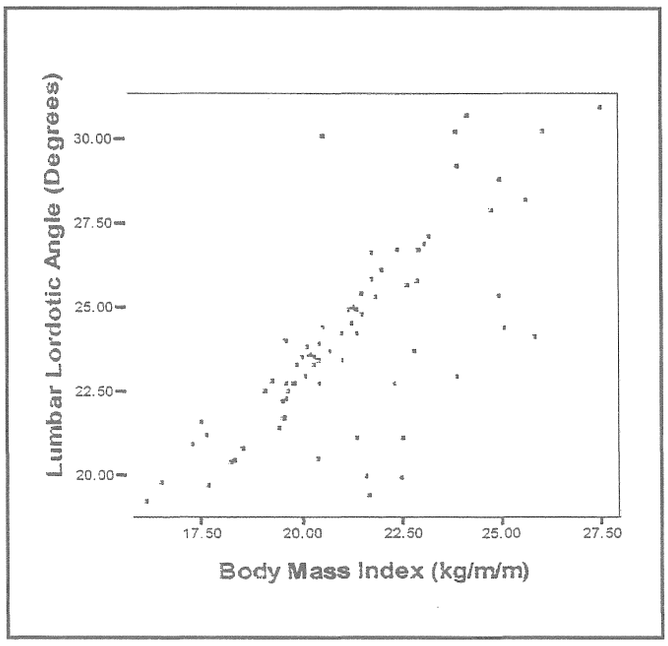

Figure 4: The relationship between lumbar lordosis and BMI

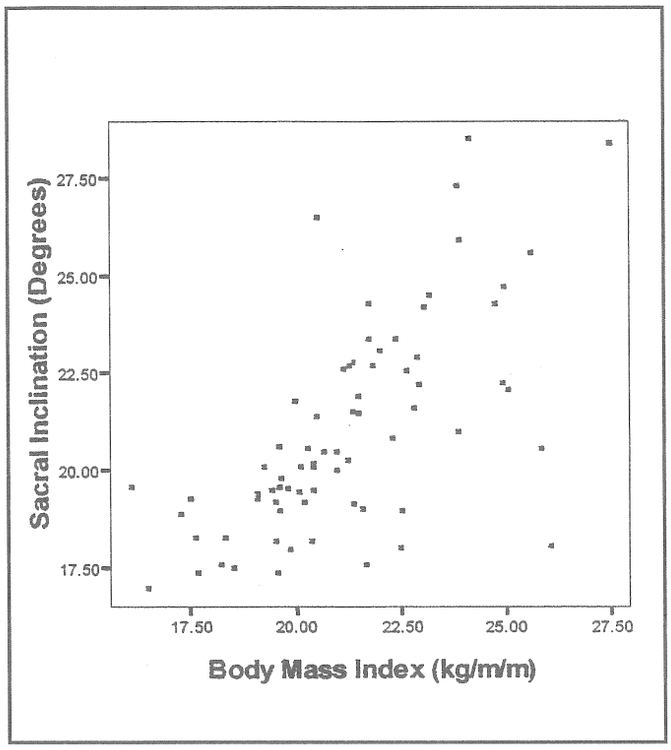

Figure 5: The relationship between sacral inclination and BMI

Results

Seventy-three subjects fulfilled the inclusion criteria. Twenty were excluded after the questionnaire and physical examination due to history of back pain, or clinically apparent lateral curvature of the spine. Of the remaining 81, 8 who passed the screening test did not consent to undress.

The Body Mass Index Profile (Table I)
Fifty-six subjects had a normal BMI (18.5 to 24.9kg/m^2). Thirteen were underweight (BMI < 18.5kg/m^2) and 4 were overweight (BMI 25.0 to 29.9kg/m^2). No subject was obese. The mean BMI for Chinese subjects were higher than the Malays or Indian patients, but there was no statistical difference (F-test=2.899, p-value=0.062).

The Relationship between Thoracic Kyphosis and BMI (Figure 3)
Regression analysis showed a significantly moderate direct linear relationship (r=0.596, r^2=0.355, p=0.031). When the BMI increases by 1kg/m^2; there would be an incremental increase of 0.759 degrees in thoracic kyphosis.

The Relationship between Lumbar Lordosis and BMI (Figure 4)
Regression analysis showed a significantly strong direct linear relationship (r=0.729, r^2=0.532, p=0.002). When the BMI increases by 1kg/m^2; there would be an incremental increase of 0.90 degrees in lumbar lordosis.

The Relationship between Sacral Inclination and BMI (Figure 5)
Regression analysis showed a significantly moderate direct linear relationship (r=0.658, r^2=0.434, p=0.020). When the BMI increases by 1kg/m^2; there would be an incremental increase of 0.753 degrees in sacral inclination.

Discussion

Tuzun et al.[1] and Amonoo Kuofi[2] showed that an increase in BMI will shift the centre of gravity of the body. Williams et al.[3] has also reported this. This shift in the centre of gravity will eventually would cause an increase in thoracic kyphosis, lumbar lordosis and eventually sacral inclination. Our study (Figures III, IV and V) confirm these relationships; and further quantifies the expected change in these sagittal parameters when a change in BMI occur. The biggest correlation was seen in lumbar lordosis (r=0.792, p=0.002); which had the biggest incremental increase (0.90 degrees/kg/m^2) with a rise in BMI. This finding also suggests that an increase in BMI tends to contribute the most change in lumbar lordosis compared to thoracic kyphosis (0.759 degrees/kg/m^2, r=0.596, p=0.031) and sacral inclination (0.753 degrees/kg/m^2, r=0.658, p=0.20). This finding also leads us to postulate; that lumbar back pain is most noticeable in the subject who is overweight or obese (BMI > 25kg/m^2).

Conclusion

We conclude that an increase in BMI causes an increase in thoracic kyphosis, lumbar lordosis and sacral inclination. This relationship is most apparent with lumbar lordosis.

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ORIGINAL ARTICLE

The Relationship Between Spinal Sagittal Profile and Sagittal Vertebral Configuration

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Summary

This is a diagrammatic explanation of the relationship between spinal sagittal alignment and sagittal vertebral configuration. The radius of curvature of sagittal vertebral configuration is linked to smoothness or sharpness of the apex of the curve in the sagittal plane. This relationship is governed by the amount of anterior height of that vertebral configuration; in which a small anterior height will give an apex which is sharp (small radius of curvature), whereas a larger anterior height will lead to a smooth apex (and a large radius of curvature).

Key Words: Sagittal spine, Radius of curvature, Vertebral configuration

Introduction

It has been long recognised that an acute angulation of an apex of a sagittal curve of the spine has an effect on the neural function because of bowstringing of the spinal cord[1,2,3]. This has been ascribed qualities such as sharp and /or angulated by many workers[4]. Conversely, a smooth curve has been called 'rounded'; and is spared neural deficit. Though well recognised, no worker has, to date (based on a medline search); described the relationship between vertebral configuration and apical quality. This study was done to address that issue.

Materials and Methods

The lateral radiographs of 112 patients who presented with congenital kyphosis (sagittal spinal deformities) were reviewed for this study. The apices of the curves were studied in all the radiographs, and the type of vertebral anomaly causing the curve was determined. The apical vertebral anomaly was classified according to McMaster and Singh's classification[5], in which there are 3 major types of sagittal configurations; *hemivertebrae* (with and without unsegmented bar), *wedge and butterfly vertebrae, and anterior segmentation* defects. The sagittal outline of all the curves were mapped on a transparency and their radius of curvature determined[1]. Then the sagittal profiles were divided into the 3 groups according to their sagittal vertebral configuration. The magnitude of the radii were then determined.

Results

The three groups had the radii of curvature of their apices falling into mutually exclusive

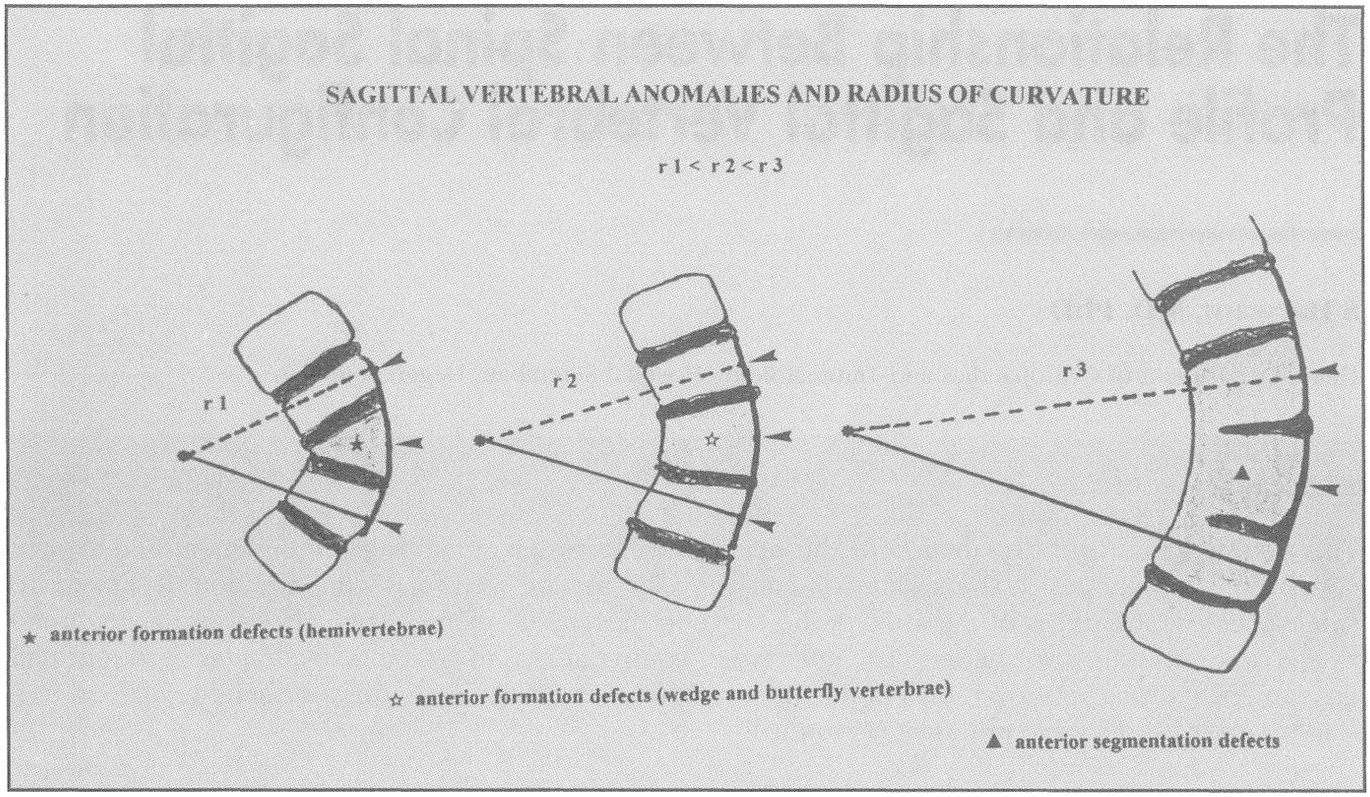

Figure 1: The diagrammatic relationship between sagittal vertebral anomalies and radius of curvature.

parameters (Figure 1). The radii of curvature of the hemivertebrae[1] (with and without unsegmented bar) were the smallest, followed by the wedge and butterfly vertebrae[2] and finally the anterior segmentation defects[3], in order of increasing radii of curvature.

Discussion

The hemivertebrae sagittal profiles with smaller radii of curvature are associated with higher proportion of neurological deficits; while the anterior segmentation defects with larger radii of curvature are associated with minimal or no neurological deficits. A previous report [1] had related to a smaller radius of curvature to neural deficits. The radius of curvature of sagittal vertebral configuration is linked to smoothness or sharpness of the apex of the curve in the sagittal plane. This relationship is governed by the amount of anterior height of that vertebral configuration (Figure 1); in which a small anterior height will give an apex which is sharp (small radius of curvature), whereas a larger anterior height will lead to a smooth apex (and a large radius of curvature).

Conclusion

From this diagrammatic study we conclude that hemivertebrae have the smallest radii of curvature, followed by butterfly and wedge vertebrae, with the anterior segmentation defects having the largest radii of curvature.

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ORIGINAL ARTICLE

Numerical Simulation of Human Femur Bone in Total Hip Replacement: The Appropriate Element Type

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Summary

In this study an approach toward the best element type for finite element analysis of human femur bone has been conducted. A comparison between frequently used 10 node tetrahedral elements with 20 node degenerated hexagonal element types has been carried out and the best elements were recognized in terms of the necessary accuracy and Central Processor Unit time for solution. Once the appropriate element type and mesh size was optimised, further study on bone behaviour in presence of implant or in intact form can be assumed as reliable and accurate. Five different global sizes of elements were used in order to achieve a range of Number of Degrees of Freedom of up to 70,000 with respect to the limits of the commercial solver. Two types of load senarios have been used to represent a simple one-legged stance, one leading to bending and the other to torsion of femur. Finite element models were solved using ANSYS. The results indicate the benefit of Tetrahedral 10 node type of elements over any other element types while using automatic mesh generation for femur mesh construction.

Key Words: Finite element analysis, human femur

Introduction

The objective of biomechanics is to investigate to quantify, and to provide clarification for tissue/tissue and tissue/device mechanical interactions. The human body is probably the most complex piece of engineering ever devised; analytical methods are unable to give appropriate answers to questions of biomechanics. Two main paths are experimental and computer aided numerical investigations. In experimental methods, calibration of measuring devices are difficult; and even more so to perform experiments *in vivo*. Nevertheless experimental methods are very important. Experimental methods are essential to validate numerical results.

Numerical analysis is the only alternative for studying the interaction of a device and tissue. Having a constitutive law, one can investigate the physics of the body in a very efficient manner and many "What if" situations can be explored. Hence these theories can suggest a scrutiny in order to

determine the nature, condition, or quality of function of the body and further more, the invasive techniques can be optimised. This study focuses on the area of orthopaedic biomechanics on the femur bone altered with a prosthetic device in total hip replacement.

Because of the complexity of many mechanical and geometric variables, Finite Element Analysis (FEA) is a crucial tool for evaluating mechanical behaviour of biological tissues like femur bone either intact or after hip replacement surgery. It is also possible to test and optimise the *in vivo* the life span of orthopaedic devices through test and optimisation of their material properties, geometric design and insertion process in order to minimise the instability.

In finite element modelling, a sound understanding of the physics of the problem allows the user to design a representative and efficient finite element mesh. In such complex tissue as femur bone, complex stress distribution and stress gradient can be expected as a result of applied loads and boundary conditions. The accuracy of the model can be improved in two ways. Either the geometry can be divided into smaller elements, so that the mesh density is increased (h-refinement) or the accuracy of the elements themselves can be improved by using higher order interpolation functions (p-refinement)[1]. In the latter one, refining element and increasing the element order from linear to quadratic elements leads to significant increase in the computer time needed to analyse. However, beyond a certain level, refinement converges the result to the correct solution minimally while increases the Central Processor Time (CPU) time.

Three-dimensional FE model of human bones are usually derived from CT scan data sets. Creation of such model is not a trivial task. Manual mesh generation needs an exhaustive effort, while automatic mesh generators (AMG), available in commercial packages, generate FE meshes of tetrahedral elements that allow the user to control over the size.

Merz[2], have presented a comparison between three different 3D AMG methods, which are generation of tetrahedral, hexahedral and voxel meshes. Lengsfeld[3], developed a finite element preprocessors for creating three-dimensional models of human femurs. It suggests and uses the brick elements, which are of advantage in terms of computing time, accuracy and computer storage requirements. Several other studies are based upon FE models with hexagonal element types [Katoozian[4], Keyak H[5], Bagge M.[6], Weinans [7]]

Polgar[8] and Viceconti[9], who carried out comparative studies on 4 node tetrahedral elements (T4) and 10 nodes tetrahedral ones (T10), concluded to avoid the automated generated T4 type elements and recommended the use of T10 parabolic elements.

The motive of the present study is to find an appropriate mesh refinement of either 20-node degenerated or 10-node non-degenerated tetrahedral element types that ascertain the levels necessary to attain convergence. Once the appropriate element type and mesh size are optimised, further study on bone behaviour in the presence of implant or femur in intact form can be assumed as reliable and accurate.

Materials and Methods

In this study, a Standardized Femur is the reference geometry. This is a public three-dimensional geometric model of a composite femur and the most recent version created by Viceconti[10] has been used.

The model has been imported in Initial Graphics Exchange Specification (IGES) format to a pre and post processor, Hypermesh (Altair). Then Boolean

operations have been implemented in order to only consider the proximal femur as a cortical shell bone. The shell was made of two surfaces named internal and external surface, which are totally irregular. Using Hypermesh built-in ANSYS template, it is possible to export the model as an ANSYS 3D database. The results were imported to finite element analysis program of ANSYS [11] [ANSYS 6.0; ANSYS Inc. USA]. The 10 node tetrahedral elements (T10) were created using *free* mesh generator of ANSYS. A free mesh algorithm has no restrictions in terms of element shapes, and has no specified pattern applied to it[12]. Two types of elements were chosen for comparison, one a 3D ten node tetrahedral structural element and the other one, a higher order version of 3D 8-node solid element. The latter one is defined by 20 nodes having three degrees of freedom per node, translations in the nodal x, y, and z directions. The model has been meshed using degenerated form of this element with 5 different global sizes, and also 5 more cases have been created by the non-degenerated form of first type above mentioned element (T10). The global size was set to represent the average edge lengths of 12, 11, 10, 8 and 6mm. Boundary conditions and material properties were assigned and the resulting model solved using ANSYS solver running on a single processor built in NT operating system. The load cases used were the same as several other literatures defined to simulate a one legged stance and the constraints were put on the distal end of femur for all degrees of freedom equal zero[8]. Due to comparative nature of this study, the amount of loading was considered only to be the same in all models; 1N. Another load case was defined to offer the bending moment of 1Nmm in the proximal region. The bone was modelled as a homogenous, linear elastic isotropic solid with E=20Gpa and v=0.3.

Results

Figures 1 and 2 show the maximum displacement variations by the increase in Number of Degrees Of Freedom (NDOF) in FE model in each load case definitions. The convergence of the results was satisfied with patch test instead of completeness or compatibility criteria of strain or strain energy. The centre of the femoral head had the maximum displacement in all mesh types and sizes. Figure 3 shows the CPU time, which has been restricted by available DOF of 70000, and also the fitted polynomial function to the given data points for CPU time. This gives a sense of rapid increase in time needed for solving equation in degenerated 20 nodes element type. The calculated displacement and stresses for the 6mm 10 node tetrahedral element model was considered to be correct while it achieved convergence. Displacement errors for each mesh refinement have been calculated and used in Figures 4 and 5 for bending and torsion respectively.

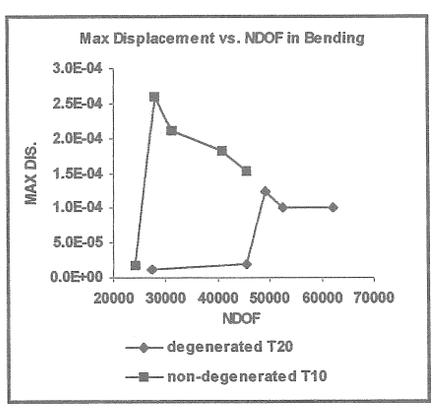

Figure 1: Maximum displacement vs. Number of DOF in bending

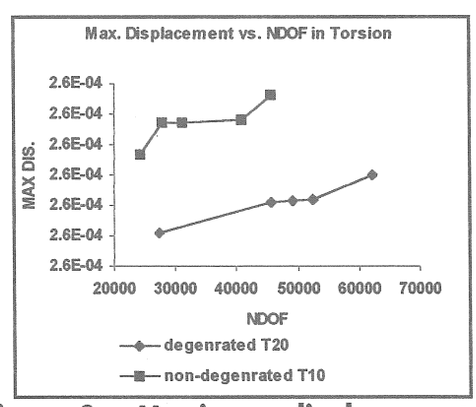

Figure 2: Maximum displacement vs. Number of DOF in torsion

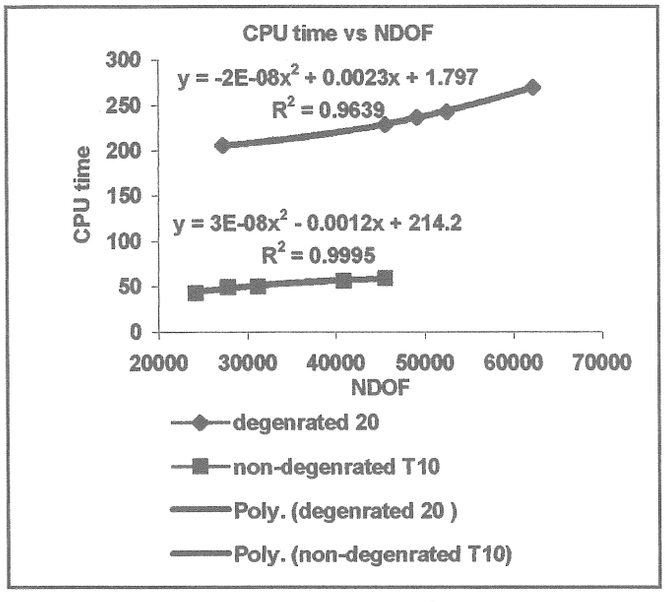

Figure 3: CPU time variations by NDOF

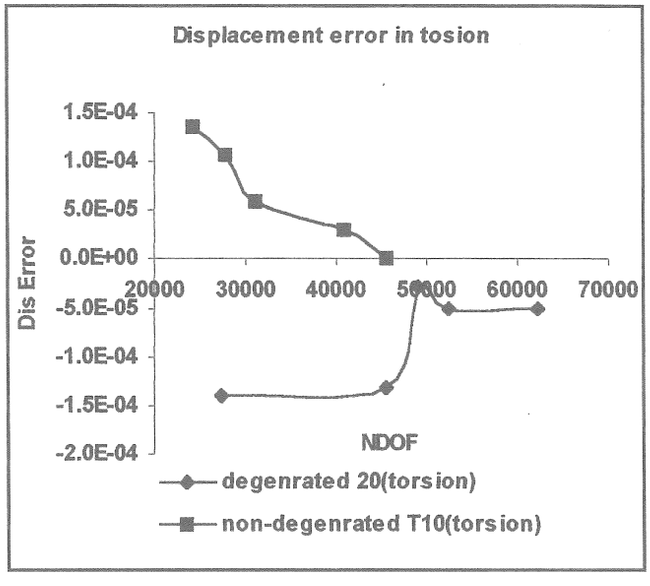

Figure 5: Displacement error vs. NDOF in torsion

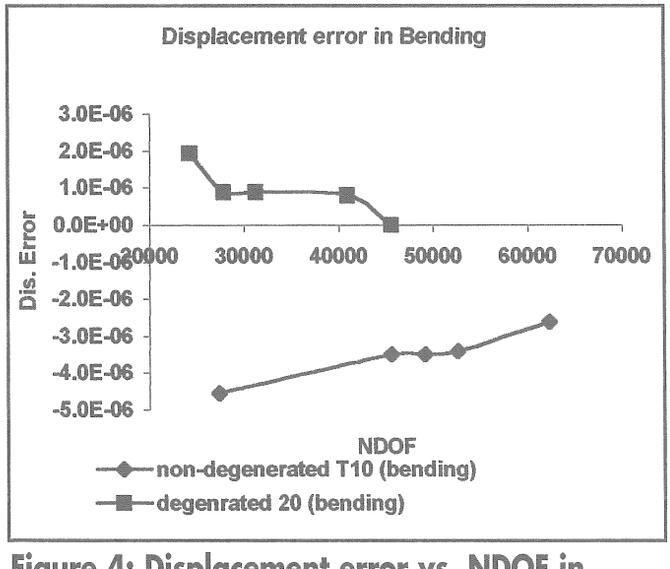

Figure 4: Displacement error vs. NDOF in bending

Discussion

This study assessed the appropriateness of 20 node degenerated hexagonal element types in the automatic mesh generation of human femur which was used in the finite element study of this complex structure. The two types of elements compared have a wide difference, clearly demonstrated in Figures 1-5. CPU time for degenerated tetrahedral elements, which have 20 nodes, was much higher than that of non-degenerated T10 type by a factor of about 4 in similar number of degree of freedom.

It is also shown in Figures 4 and 5, in the calculated displacement for the two types of refined models in either load cases, the solution converges to higher values for 20 node degenerated elements while it still varies for the torsion senario around 50,000 degrees of freedom.

Conclusion

Considering both accuracy and CPU time for solving the mode; from these results we conclude that for meshing a human femur bone with automatic mesh generators, a T10 type of element is appropriate. We further recommend to avoid the use of any higher order versions of three dimensional solid elements.

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ORIGINAL ARTICLE

Short Term Results of Displaced Intra-Articular Fractures of the Calcaneum

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Summary

We performed a prospective study of 20 patients with displaced intra-articular fractures of the calcaneum with Type II and Type III Sanders classification between the periods of November 1993 to September 1995. Their ages ranged between 17 to 48 years with a mean of 33 years. All these patients were initially assessed by CT scan and classified according to Sanders Classification. The first 10 patients were treated operatively through an extended lateral approach and the next 10 patients were treated conservatively. Both groups were encouraged early mobilization of the ankle and subtalar joint with non-weight bearing for at least eight weeks. All 20 patients were reviewed regularly at six weeks, three months, six months, nine months and the final assessment was made one year after injury. Clinical assessment used the modified scoring system of Crosby and Fitzgibbons, and modified assessment by Palmar et al. We found significantly better results in the operated group with respect to pain, return to work and deformity. The results are also dependant to the type of the fracture. Radiologically, no significant collapse or loss of reduction was noted in both groups after one year. We conclude that the operative treatment of intra-articular fractures of the calcaneum gives better short-term results than conservative treatment. However, we need to continue the study and compare long term follow up to provide more objective long term results.

Introduction

The calcaneum is the tarsal bone most likely to fracture. It accounts for 60% of tarsal bone fractures and about 2% of all fractures[1,2]. Most of these fractures are intra-articular and following falls from height. Intra-articular calcaneum fractures have been very difficult to treat. In the earlier days, most of these fractures have been treated conservatively, with various methods, and the results, generally unsatisfactory[3,4,5,6,7,8].

Open reduction became a recognised method of treatment only after the work of Palmer[9]. Since then there have been many different regimens advocated for the treatment of displaced intra-articular fractures.

Many studies have shown better results with operative treatment, but comparison of clinical series has been complicated by lack of consistency in classification of intra-articular fractures and evaluation of results.

At present time, there remains no consensus regarding classification, indication of surgery, type of surgery or post-operative management of these fractures.

Although these fractures are rare in our country, almost all our patients with intra-articular fractures were treated conservatively.

Hence we commenced this study because we believe that displaced intra-articular fractures should be treated on the same principles as any other injury of the weight bearing joints i.e. by anatomical reduction and rigid fixation to allow early movement and weight bearing.

Even though the study group is small, with our early result we hope to provide new information regarding management of intra-articular calcaneum fractures and hopefully improves the orthopaedic management.

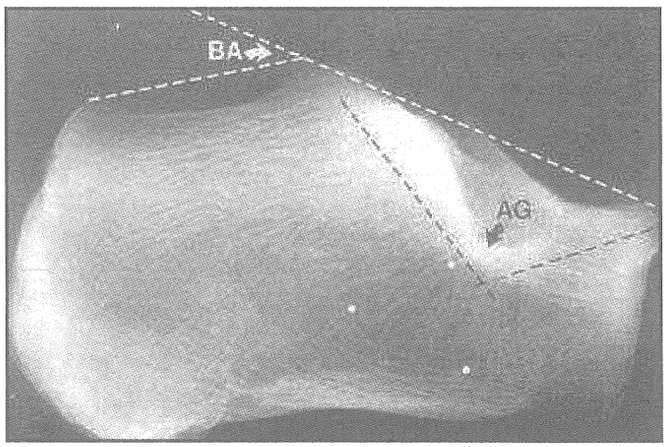

Figure I: Bohlers and Angle of Grissane

Anatomy

The calcaneum is the largest tarsal bone in the foot and it is well designed to withstand the stresses of daily living[10]. It articulates with the talus above and the cuboid in front. The bone is mostly cancellous with thin cortical shell and multiple ligamentous and tendinous attachments.

The calcaneum has 4 main parts: firstly, tuberosity, where the tendo-achilles inserts, has no articulation but has medial and lateral processes on its plantar aspects. Secondly, the body bears the posterior facet superiorly, which articulates with a similar facet on the talus. Next, the sustentaculum tali carry the middle and the anterior articular facets separated from the posterior facet by sulcus calcanei. The later constitutes the floor of the sinus tarsi and receives the insertion of the interosseous talocalcaneum ligament. Lastly the anterior process gives origin to the bifurcate ligament which inserts into the cuboid and the navicular and articulates with the cuboid. The subtalar joint complex is formed by the posterior talonavicular joint and the acetabulum pedis lodging the talar head. The basic motion at this joint is that of the male ovoid surfaces moving over female ovoid surfaces and vice versa. The motion generated at the joint is flexion-supination-adduction or extension-pronation-abduction.

Angle of Grissane (GA) (Figure 1) is the angle formed by the posterior facet and the line from the sulcus calcaneum to the tip of the anterior process. It varies from 120° to 145°. The bone making up the angle is a thick and strong cortical strut that supports the lateral process of the talus. The Bohler's angle (Figure 1) is the angle between the two lines originating from the highest point on the posterior face on the lateral radiograph. One line goes to the upper border of the anterior process. The other goes to the upper border of the tuberosity. The normal value is 25° to 40°.

Mechanism of injury

The tuberosity of the calcaneum is slightly lateral to talus. The biomechanics of the injury involved axial loading of talus on the calcaneum. When an axial load is applied to a foot whose heel is planted on flat surface, the posterolateral edge of the talus fractures the calcaneum obliquely[11]. This may cause either extra or intra-articular fractures

based on whether this fracture avoids or involves the posterior facet.

Anteriorly, the fracture may exist, laterally, usually at the angle of Gissane, but occasionally it may progress distally as far as the calcaneocuboid joint. Posteriorly the primary fracture line lies more medially, separating the calcaneum into 2 main fragments; the sustentacular or constant fragment, and the tuberosity fragment.

Depending on the severity of the injury, this will result in either simple, non or minimally displaced fractures or more comminuted fractures. If the force is purely axial, a secondary fracture line will appear beneath the facet, exiting posteriorly and resulting in a tongue-type fracture, as described by Essex-Lopresti[5]. And it will cause joint depression-type fracture if the load is slightly more horizontal. In these cases, the secondary fracture line may create a free lateral piece of posterior facet, separate from the tuberosity fragment.

This latter piece is also known as the semilunar fragment, the comet fragment or the superiolateral fragment. With further axial force, the talus with the constant sustentacular fragment continuous its medial slide, shortening and widening the heel. And the posterolateral piece of the posterior facet down into the tuberosity fragment, rotating it as much as 90^0. This results in an explosion of lateral wall that may extend as far anteriorly as the calcaneocuboid joint.

Materials and Methods

In the period of November 1993 to September 1995 all patients who have attended the University Hospital with displaced intra-articular calcaneum fractures diagnosed by plain radiography (anteroposterior and lateral) have been admitted for treatment and investigation. Initial treatment was by elevation of the leg and the application of ice packs. Inclined coronal and axial CT Scans were performed on all patients.

The fractures were classified according to Sanders[8] (CT Scan) classification. Only patients with Type II and Type III Sanders classification were entered into the study (21 patients), to receive either conservative or operative treatment.

The first 11 patients were treated operatively and next 10 patients were treated conservatively. The conservative treatment consisted of elevation of the injured leg on a Bohler-Braun frame for 5 to 7 days. Ice packs were applied to control swelling, and passive movements of the foot were encouraged soon after the pain and swelling settled.

In the operative group, surgery was performed within the first two weeks when the swelling subsided, to prevent difficulties with reduction secondary to early consolidation of the fracture. Intraoperative fluoroscopy was performed to check the reduction. The choice of fixation is based on complexity of the fracture and personal preference; either 3.5mm reconstruction plate, anterior cervical or H-plate, one-third tubular, etc. In some of the patients, the defect was grafted. Post-operatively, subtalar and ankle motion were encouraged as soon as possible. A repeat CT Scan post-operatively is then obtained to evaluate the reduction.

Rehabilitation

Early subtalar and ankle movement were encouraged in both groups. The patient is kept non-weight bearing for at least eight weeks with progressive weight bearing begun after that full weight bearing is allowed by three months.

Assessment

The patients were followed-up at six weeks, three, six, nine and twelve months, with complete assessment done at twelve months. For assessment from the history, we used modified

scoring system of Crosby and Fitzgibbons[12] (Table I).

For evaluation of outcome by clinical examination, we used modified assessment by Palmer, Triffitt and Gregg. Radiological assessment was made from lateral recording Bohler's angle and height of calcaneum.

Table I: Assessment Criteria and Scores (Modified scoring of Crosby and Fitzgibbons, 1990)

Criteria	Score
Pain (visual analogue scale)	0-20
Walking ability	
Unlimited	20
Indoors only	10
Unable to walk	0
Sural nerve involvement	
No	10
Yes	0
Employment	
Same job	20
Changed job	10
Unemployed	0
Shoes	
Normal shoes	10
Modified shoes	0
Duration of absence from work	
12-20 weeks	20
21-30 weeks	15
31-40 weeks	10
41-52 weeks	0

Statistical Analysis

Although the number of patients was small, the mean and standard deviation were calculated for the results that could be compared from the history. Unpaired treatment test were used to compare between operative and conservative group. The level of significance was set at $p<0.05$.

As for the outcome of clinical examination, chi-square test were used to compare operative and conservative groups and the level of significance was set at <0.05.

Table II: Demography

Criteria	Operative		Conservative	Total
Sex				
Male	9		1	10
Female	92		1	10
Mean Age	33.7(17-48)		32.6(21-44)	-
Site of injury				
Right	4		5	
Left	6		5	
Mechanism of injury				
Fall from height	9		1	
MVA	9		1	
	Bone Graft	**No bone graft**		
Fracture type (Sanders)				
Type IIA	0	0	1	1
Type IIB	0	1	1	2
Type IIC	0	1	1	2
Type IIIAB	3	3	3	9
Type IIIAC	2	0	3	5
Type IIIBC	0	0	1	1

Results

There were twenty-one patients from this study, eleven patients were operated and ten patients were treated conservatively (Table II). Out of these, in the operated group, there were ten males and one female and in the conservative group, there were nine males and one female. One of the patients from the operated group is also a known schizophrenic who defaulted treatment and was thus not assessed in this study.

Seven patients had associated injury; four with spine injuries without neurological deficit, two with fracture of the lower end of the radius and one with fracture of the medial malleolus. Only Type II and Type III Sanders' CT Scan

Table III: Overall results

		Pain	Walking Ability	Medical Leave	Job Change	Sural Nerve	Shoe Change	Total	Bohlers angle (Degrees)		Calcaneum height (cm)	
									Initial	1 year	Initial	1 year
IIA	operative	-	-	-	-	-	-	-	-	-	-	-
	conservative	14	20	15	20	10	10	89	20	20	4.1	4.1
IIB	operative	14	20	20	20	10	10	94	20	25	3.6	4.1
	conservative	12	20	15	20	10	10	87	15	15	3.7	3.7
IIC	operative	14	20	15	20	10	10	89	15	20	3.9	4.5
	conservative	12	20	15	20	10	10	87	15	15	4.3	4.3
IIIAB	operative	12	20	15	20	8	10	86	15	25	3.5	4.1
	conservative	9	20	13	20	10	10	82	20	20	3.9	3.9
IIIAC	operative	10	20	13	20	10	10	82	5	15	3.6	4.2
	conservative	8	20	12	20	10	10	80	5	5	3.5	3.5
IIIBC	operative	-	-	-	-	-	-	-	-	-	-	-
	conservative	6	20	10	10	10	20	76	5	5	3.5	3.5

Classification were included in this study. The fracture patterns were predominantly types IIIAB and IIIAC.

Assessment of the patient was done as per the protocol (Table II).

Type IIA
There was only one patient in the conservative group and no patients in the operative group. The clinical grading for this patient is shown in Table III. The clinical result was good. Clinical examination showed that he only had calf wasting and was functionally normal with no neurovascular deficit. No other deformity was noted. His ankle and subtalar movement were more than 50% of the normal side.

Type IIB
There was one patient in each group; excellent results were obtained in the operative group and good result in the conservative group. Radiographic evidence showed that we were able to elevate approximately 5^0 and increase the height of the calcaneum by about 0.5 cm with operative treatment.

Type IIC
There was one patient in each group. The result was good in both groups. The patient with operative treatment had slightly less pain compared to the patient who had conservative treatment. Clinically both patients have lateral bossing and calf wasting. Their ankle and sub talar movement were >50% of the normal side. They had good function and no neurovascular deficit.

Type IIIAB
There were nine patients in this group: 3 were treated conservatively and six had operative treatment. Of the six patients who had operative treatment, 3 also had bone grafting and 3 did not. The breakdown of clinical results in group IIIAB were as follows: 1 excellent, 4 good and 1 fair in the operative group and 2 good and one fair in the conservative group. The patient with fair result in the operative group, all the patients both in the conservative and operative groups had calf wasting.

Two patients in the operative group had valgus deformity of the foot and one of these patients had a flat longitudinal arch. There was also one patient with lateral bossing. Three patients had ankle and subtalar joint of more than 50% of the normal side and two patients with both ankle and subtalar joints of less than 50% of the normal side. Besides calf wasting, all patients in the conservative group had lateral bossing. All patients had ankle movement more than 50% of the normal side and subtalar movement of less than 50% of the normal side. Two patients were able to walk without a limp. All patients could not stand on their tip-toes. One patient in the operative group walked with a limp. Other patients were able to walk normally.

Radiographically, only 5 patients in the operative group that could be compared. Three out of the 5 patients were treated with bone graft and showed about 100 elevation of Bohler's angle and increased height from 0.6 cm to 0.9cm. No further collapse was noted. There was one patient treated conservatively who showed further collapse, decrease Bohler's angle of about 5^0 after one year. No further collapse was seen in the others. Overall in this Type IIIAB, operative management shows better result than conservative.

Type IIIAC
There were 5 patients in this group. As seen in Type IIIAB, the differences between the two groups were in the severity of pain and time of return to work. From a clinical point of view, the outcome of the two groups were almost the same. All patients had calf wasting and subtalar joint movement of less than 50% of the normal side. There was one patient with ankle movement of

more than 50% and the other was less than 50%. On assessment of function, both patients walked with a limp. In the conservative group, there was one patient with all deformities, both ankle and subtalar movements of less than 50% and walking with a limp.

The other two patients had calf wasting and lateral bossing. One of these two patients had ankle movement of more than 50% on affected side and able to stand on tip-toes. Radiographically, no further collapse was noted in both groups in either the Bohler's angle or height loss.

Type IIIBC

There was only one patient in this type and he was treated conservatively. The result was fair. From clinical examination this patient had all the deformities and restricted ankle movement. He was noted to walk with a limp.

Overall Result

There were significant differences between the two groups of patients in the degree of pain experienced and the period of absence from work. There was one patient in the operative group with sural nerve hypoasthenia. There was no difference in the walking ability, ability to return to original work or change of footwear. The overall clinical grading of the two groups are shown in Table III.. Of the patients in the operative group, 20% had excellent results, 70% had good results and 10% had fair result. None of the patients had a poor result.

From clinical examination, all 20 patients showed calf wasting. Valgus deformity was more predominant in the operative group (2 patients - 20%) as opposed to lateral bossing being predominant in the conservative group (8 patients - 80%).

Ankle movement assessment showed that 80% of patients in the operative group had more than 50% ankle movement compared to the normal side. In the conservative group however it was 70%. Comparing subtalar movement, 50% of patients had more than 50% movement compared to the other side whereas in the conservative group, it was only 30%. Good function was seen in 70% of patients in the operative group compared to 50% in the conservative group. Sural nerve involvement was seen in only one patient in the whole study and he was from the operative group.

Radiologically, one patient, who had fracture Type IIC, who was operated had a decreased Bohler's angle of approximately 2^0 one year after the injury and one patient in Type IIIAB who was treated conservatively showed a further decrease of about 5^0.

No further collapse or decrease in height was noted in any of the other patients from both groups. Most complications in intra-articular calcaneum fractures are late complications. Early complications are related to operative intervention. As most fractures of the calcaneum are closed, the risk of infection from operative intervention are the most significant.

There were two patients (20%) with superficial infection that required debridement but no implant needed to be removed. One of these patients had a compound fracture and was operated two weeks after the injury.

One patient, a known schizophrenic who defaulted treatment, presented within the study period after more than one year with chronic infection. Debridement and removal of implant was done and subsequently, the wound healed well. This patient has not been included in our study.

Discussion

The calcaneum is the most common tarsal bone to fracture. The prognosis for an extraarticular fracture is uniformly good, but for an intraarticular fracture is very varied. The management of intraarticular fractures of the calcaneum has undergone a great deal of change in the past 10 to 15 years. There has been a major shift in the philosophy of management of these fractures from a relatively conservative mode to a more aggressive surgical treatment. This shift was encouraged by the advent of more advanced imaging modalities especially three dimensional computer tomography. The lateral approach has also gained more popularity and today is the preferred choice of treatment.

In our study both groups had similar demographic data and 90% of patients sustained the injury following a fall from height while the remaining were from motor vehicle accidents. Four patients (20%) had associated vertebral fractures and their calcaneal fracture was of a more severe type.

Only Sanders classification Type II and III were included in this study because Type I fractures are undisplaced fractures which have good result with closed treatment and Type IV fractures are so severe that even experienced surgeons may find it difficult to piece the fracture together and may need primary fusion.

In our series, there were 5 patients (25%) in Type II with no significant difference between the outcome between operative and conservative treatment. However, in patients with operative treatment, the severity of pain on prolonged walking and duration of absence from work are less than the conservative group. On further evaluation, one patient with excellent result in Type IIB had good anatomical reduction of the posterior facet after operative treatment. There was no significant further collapse of the calcaneum after 1 year in both groups.

The one patient with excellent results in Type III, after operative treatment, had good anatomical reduction radiologically and her occupation placed little demand on her foot. We agree with Sanders that in the operative group, Type II displaced intraarticular fractures of the calcaneum shows better results than in Type III. This may be because Type II were easier to fix to get nearly normal anatomical reduction. We also agree that joint reduction when technically possible, is easy through the lateral approach as well.

Our overall results between both groups shows significant differences in the severity of pain, duration of absence from work and lateral bossing. The overall assessment results were much better in the operated group. Even though all patients had pain on prolonged walking, the severity was minimal. In the conservative group, most patients had more severe pain compared to the same Type in the operative group. These findings were same as that found by Leung, Yuen and Chan[13]. Functionally, the operated group had a shorter period off work. However, in conservative group, our patients returned to work much earlier. (28.6 ± 3.27 weeks. compared to 38 ± 6.3 weeks). This may be because most of our patients are labourers who need to support their families.

The main limitation in this study are the follow up time and the small number in the study group especially when they were classified into different types. The result might not be representative to the particular study. The short follow-up time probably does not misrepresent the results. The results of calcaneal fractures have been reported to continue to improve over the first two to four years after the injury and eventually reach a plateau between four to six years. Therefore, results evaluated under this period underestimate rather than overestimate the result. It is also difficult comparing result in this series with the result reported in literature because of different classification and criteria for assessment being used to assess the patient.

Displaced intraarticular calcaneal fractures deserve an aggressive well planned surgical treatment similar to any other intraarticular fracture. As in other recent studies we have shown that our operative treatment of displaced intraarticular fractures of the calcaneum gives much better results than conservative treatment in both types in respect to pain, duration of absence from work, deformity and ankle and subtalar movement. We found that worse results were noted in patients with more severe fractures in both groups. This coincides with the findings of Sanders who pointed out that CT Scan is the only accurate method of analysing these complex fractures and therefore only CT Scan classification can be prognostic.

The sural nerve remains at risk in any lateral approach to the ankle. There was one patient who sustained injury to the sural nerve. This was the patient who also had superficial wound infection.

Most of the patients in the conservative group were noted to have deformities and complained of more severe pain. This was most probably due to the deranged subtalar joint or structures being compressed between the bulging lateral wall and the lateral malleolus.
Further treatment should be considered if pain persist for more than 18 months or if it results in prolonged disability and the patient is unable to return to original work. Even though all patients in this study have some degree of pain, they were able to return to their original occupation.

In our series there were only two cases of superficial infection and both readily resolved with debridement and one patient with sural nerve injury. There was no significant further collapse or loss of reduction of the calcaneum in both groups. Our early results are encouraging but we need a bigger study group and also need to compare the long term results to provide more scientific evaluation of the indications and the advantages of open reduction and internal fixation with this approach.

Conclusion

The treatment of intraarticular fractures of the calcaneum will remain a dilemma in the foreseeable future. Despite the evidence which show marginally better results from surgical treatment, the slow learning curve and the potential for complications like infection and sural nerve injury should make one tread cautiously when attempting a more aggressive mode of treatment. However, the present day state of the art imaging techniques and ever improving implants available will continue to tempt the more adventurous orthopaedic surgeon to venture into the domain of more invasive treatment.
For the present though, the occasional encounter with the intraarticular calcaneal fracture should either be left for the more experienced hands within our fraternity or for mother nature to take its arduous but definitive (and often effective) course.

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ORIGINAL ARTICLE

One Year Outcome of Hip Fractures in the Elderly

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Summary

A one year follow up was conducted on 87 patients above the age of 60 years who sustained a hip fracture subsequent to a trivial injury. All patients admitted to the University Malaya Medical Center between October 1995 and September 1996 were screened and treated following standard treatment protocols. An activity of daily living index i.e. the Barthel Index was administered both at admission and one year later. Information was obtained either through the telephone or directly from the patient at the clinic. The one year mortality rate was 26% while that at six months was 22%, with patients in the above 80 years group showing a 50% mortality. We found no correlation between the mortality rate and the duration of hospital stay, delay before surgery, ASA grade premorbid medical conditions, type of fracture or premorbid activity level. More than half the patients regained their premorbid Barthel Score. There was no deterioration of dependency after three months following discharge. The mortality rate was similar to other studies. The level of disability following fracture suggests ongoing home is needed and that domiciliary rehabilitation within the first six months of discharge may be needed.

Introduction

Fractures of the hip remain as one of the most common and potentially devastating injuries in the geriatric population. Improvements in the quality of life and with it the standard of medical care has inadvertently brought about a much higher incidence of fractures of the proximal femur in the elderly. The purpose of this study was to look into the one-year outcome of fractures of the hip in the elderly, with specific emphasis to determining the level of functional independence and mortality.

In the Finnish study published by Kannus et al[1], there were an estimated 1.66 million hip fractures worldwide in 1990. According to projections by the World Health Organization[2] there will be a total of 53 million men and women who are 65 years of age and older in Asia by 2050. In a study done by Chong M.L[3]. et al at the Kuala Lumpur General Hospital, the incidence of hip fracture in Malaysia was 0.48% in 1981 and 0.70% in 1989.

In view of the age and general medical conditions of patients who sustain fractures of the neck of the femur, the mortality or quality of life after treatment is the best measure of outcome[4]. There are numerous indices of activities of daily living that are described in literature. Among the more commonly used indices are Katz Index of daily

living, the Barthel index (Maryland disability index), the PULSES profile, etc.

In orthopaedic practice, there is a general tendency to equate bony union in anatomical position as the best indicator of the outcome of the fracture. Radiographs quite often are used as the measure of the success of treatment. However hip fractures in the elderly are a far exception from the norm in that the incidence of non-union in intertrochanteric fractures - the only type almost always treated with fixation, is relatively low. On the other hand, poor outcomes in terms of function make an otherwise perfect reduction and union, futile. This necessitates the need for an outcome score that measures the true result of the various modalities of treatment. It is in view of this that ADL scores have an important role to play in the assessment of proximal femoral fractures in the elderly.

The Barthel Index (Maryland Disability Index) was first described by Mahoney and Barthel in 1965. It uses a rating of 10 aspects of daily living to produce and overall score of 0-20. The categories used in the Barthel Index are: Feeding, movement from wheelchair to bed and return, personal toilet, getting on / off chair, bathing self, walking on level surface, ascending and descending staircase, dressing, bowel control finally, bladder control.

In their review of Scales of Activities of Daily Living, Mary Law and Lori Letts[5] gave the index excellent scores in terms of purpose, clinical utility, Scale construction, standardization, reliability (including inter-observer consistency) and validity. They thus gave an overall excellent score for the Barthel index.

The advantage of the Barthel Index is its simplicity. Furthermore, the score can easily be obtained over the telephone through the patient's caregiver. This was affirmed by K. Laake et al[6] who stated: "The reliability of the Barthel Index is known to be high, even when the data are not collected by direct observation".

Materials and Methods

All patients over 60 years of age admitted with a new hip fracture to the University Hospital Kuala Lumpur between October 1995 and September 1996 were screened for this study. The inclusion criteria were patients above the age of 60 with a fresh hip fracture sustained from trivial injury. Patients with pathological fractures and subtrochanteric fractures or fractures of the greater trochanter only, were excluded from the study.

A detailed history of any medical problems was obtained from the patient and close relatives (or a caregiver if the patient was confined or resident in an institution at the time of the fracture), and also from the medical notes. Activities of daily living - Barthel score - was performed based on the prefracture status of the patient.

Fractures were classified using Garden's classification for neck fracture and Boyd & Griffin's classification for intertrochanteric fractures. Basal neck fractures were included as extracapsular fractures as their behavior and treatment follow the intertrochanteric variety.

All patients were admitted to the hospital and routine blood investigations were done including serum calcium, serum phosphate and serum Albumin levels. They also had radiographs of the chest and ECGs done as a preoperative assessment. They were listed for surgery where indicated at the earliest available date. Prior to surgery they were reviewed by the Anaesthesiologist and ASA grading was done. Patients requiring medical stabilization were referred to the physician or to the resident geriatrician.

Surgery was done under either general anaesthesia or spinal or epidural anaesthesia. All patients received 3 doses of prophylactic antibiotics. The methods of treatment employed at our center were generally following the principles described earlier. Patients with undisplaced femoral neck fractures i.e. Garden Types I and II were treated either conservatively or with cannulated screws. Those with Garden Types III and IV were treated by hemiarthroplasty, with the Thompson, Austin Moore or a bipolar prosthesis. Intertrochanteric fractures on the other hand were treated with either a Dynamic hip screw, or Gamma nail or Dynamic condylar screw.

Post operatively, total duration of hospital stay and time to full weight bearing was noted. X-rays were done to note correct positioning of the implant/screws and also appropriate fracture reduction.

Rehabilitation was commenced on the first postoperative day. As soon as the patient was pain free, they were encouraged to sit out of bed. If the implant was noted to be well positioned and/or the fracture reduced, weight bearing was commenced. They were encouraged to ambulate with the help of a walking frame soon after the operation. Patients were discharged generally by the fifth to seventh postoperative day unless some medical problem or infection preempted it. At the time of discharge, they were advised when to return for stitch removal and given a follow-up date in the outpatient clinic. Patients who were noted to be slow to return to walking were also give an appointment in the rehabilitation clinic where there were gradually helped into returning to normal function.

Patients were advised to come for follow-up at 3-monthly intervals, and were followed-up for up to one year from the date of fracture. X-rays of the affected hip were taken and reviewed. One year after the fracture patient (or caregiver if patient was unable to communicate) was reviewed in the clinic or over the telephone and information obtained about their place of residence, intercurrent admissions and a Barthel score were performed. If the patient had died, the date and cause of death was ascertained from the medical records or the immediate relatives.

Table I: Patient population

Factor	Categories	Percent
Age at fracture	61-69	16.1
	70-79	39.1
	above 80	44.8
Race	Chinese	71.3
	Indian	13.8
	Malay	13.8
Duration of stay (Pre op)	0-4 days	48.3
	5-9	40.2
	10-14	8.0
	15-19	2.3
	>20	2.3
ASA grade	1	9.2
	2	75.9
	3	11.5
	4	3.5
	5	0
Fracture Type	Garden 1&II	19.5
	Garden III &IV	35.6
	B&G I	20.7
	B&G II	20.7
	B&G III	3.4
	B&G IV	0
Barthel Index	20	80.5
	19	4.6
	18	5.75
	17	1.15
	16	4.6
	<16	3.45
Medical comorbidities	none	46
	1	27.6
	2	25.3
	4	1.15

Table II: Mortality after one year

Factor	Categories	Mortality Percent
Pre op hospital stay (days)	0-4	24
	5-9	29
	10-14	14
	15-19	50
	>20	50
Total hospital stay (days)	0-5	75
	6-10	42
	11-15	14
	16-20	7.4
	>20	20
ASA grading	1	0
	2	24
	3	60
	4	33
	5	0
Fracture Patterns	Garden 1&II	17
	Garden III&IV	29
	B&G 1	28
	B&G 2	33
	B&G 3	0
	B&G 4	0
Barthel score	20	24.3
	19	0
	18	40
	17	0
	16	75
	<16	33.3
Age group	60-69	12
	70-79	11
	>80	50

Results

There were 112 patients with proximal femoral fractures and 87 patients met the selection criteria. Out of the 87 patients with relevant data at the end of one year, twelve patients were Indian, twelve were Malay, 62 were Chinese, and one was Caucasian (Table II). There were 22 male and 65 female patients. Of the males, 5 were Malay, 13 Chinese and 4 Indian. The predominant group was female Chinese of which there were 50 patients i.e. more than 50 per cent of the total group studied. The patient's ages ranged from 63 years to 90 years with a mean of 77.66 years. They were divided into three different age groups for purposes of tabulation, namely 60 to 69 years, 70 to 79 years and the third group, those above 80 years. There were fourteen patients between 60 to 69 years, 34 patients in the 70 to 79 age group and 39 patients above 80 years of age.

The preoperative stay ranged from zero to 21 days. The mean was 5.66 days and median was 5.00. The majority of patients spent between zero to nine days (76 patients) before surgery. The post-operative stay ranged from 2 days to a total of 34 days, the mean being 15.51 and the median 17.00. The majority of patients spent 17 days or less while a handful of patients spent more than 20 days after surgery.

The majority of patients fell into the Grade 2 of the ASA grading, with 66 patients in that group. The remaining patients were evenly distributed among the other grades. There were no patients in grade 5. Forty eight of the patients had sustained a neck of femur fracture while the remaining 39 sustained an intertrochanteric fracture. Patients who had an undisplaced neck of femur fracture i.e. Garden I and II were 17 in number, whereas there were 31 patients with displaced fractures. (Garden 3 and 4) Eighteen patients sustained a simple two part intertrochanteric fracture while eighteen more sustained a four-part extracapsular fracture.

A total of 70 patients presented with a Barthel score of twenty. Only 3 patients had a Barthel score of less than sixteen. At the end of one year, of the survivors, 36 patients managed to maintain their premorbid score. Ten patients saw their functional score drop by one, six, a drop of two, two saw a drop of three points and one patient saw his score drop by four points. The remaining

eight survivors had an activity level score drop of more than five points.

There were a host of medical conditions encountered. Among the more common ones were hypertension, diabetes mellitus, cerebrovascular accidents, dementia, ischaemic heart disease, bronchial asthma etc. The patients were categorized according to the number of premorbid medical conditions existent. There were 40 patients with no medical conditions diagnosed at the time of admission; of these, 31 survived and nine died at the end of one year. Twenty-four patients had one premorbid medical condition and of these seventeen survived. Twenty-two patients had two medical conditions, and this group saw seven mortalities at the end of one year. The only patient with four medical problems was noted to have survived at the end of one year.

There were 23 deaths (Table II), giving a mortality of 26% at the end of one year. The mortality at 6 months was 21.8% i.e. 82.6% of deaths occurred in the first 6 months. There were 16 Chinese, 3 Malays and 4 Indians. Of the total number of patients, the percentage of patients who died (according to racial breakdown) were Chinese 16/62 (25.8%), Malays 3/13 (23.07%) and Indians 4/12 (33.3%).

Female deaths were 14 and male 9. This accounted for 21.5% female deaths (14/65) and 40.9% male deaths (9/22) at the end of one year.

Two patients (11.76%) were in the 61-70 age group, 4 patients (11.11%) in the 71-80 age group and 17 patients in the 81-90 age group (50%).

The duration that these patients had to wait before surgery was as follows:-

Six patients waited 3 or less days, 2 from 10-12 days and 2 had surgery delayed for more than 12 days. The total duration of stay for these patients ranged from 1 to 34 days. One patient stayed for less than 5 days, 5 stayed between 6-10 days, 5 more between 11 and 15 days and 12 patients were admitted for more than 15 days.

Femoral Neck fracture was the injury sustained in 10 of the patients who died while the remaining 13 had intertrochanteric fractures.

Only 2 of the patients were from nursing homes at the time of the injury.

On reviewing the medical conditions of the patients, 9 of them had no history of any medical conditions pre injury, 7 had 1 preexisting medical condition while the remaining 7 had 2 preexisting conditions.

The ASA grade of the mortality group ranged from 2-4. There were 16 patients with grade 2, 6 patients with grade 3 and 1 patient with grade 4. None of the patients were of grades 1 or 5.

Discussion

In Malaysia based on the last national census, with a population of 21.67 million in 1991, there were 1.267 million persons above the age of sixty years, amounting to more than five percent of the population[7]. Thus based on Chong L.M.'s estimate of 0.70% hip fracture rate in Malaysia, there would have been approximately 887 hip fractures among the elderly (above 60 years of age) throughout the country in 1991. With the predicted population growth, the estimated number of hip fractures in the whole country in 1998 would easily cross one thousand.

The gross misrepresentation in racial distribution was in no way reflective of the national figures but however the catchment area of the University Hospital was a predominantly Chinese-populated area, with there being only a small percentage of Malays and Indians. Hence unless statistics of the

catchment area were available (which were not), one could not draw conclusions about the incidence of these fractures among the various groups. Consequently, figures on mortality and poorer outcome in certain racial groups cannot be read with too much meaning.

Although the selection criteria was to include only patients above 60 years of age, we found that there were hardly any patients below 60 years and that the curve shifted more towards the older age groups. There was only a small percentage in the 61-60 age group and the majority was crowded in the above 80 years age group (39/87) - close to 50 percent of the patients. The progression of osteoporosis in both men and women increases exponentially and thus the presumption that there will be more hip fractures in the more elderly is a justified one.

The common medical problems that were seen in these patients were not unique to this group but rather one that was prevalent in other patients of the same age group. They were, among others, diabetes mellitus, hypertension, ischaemic heart disease, and previous cerebrovascular accidents.

The one-year mortality rate was 26%, which was similar to many western studies[8,9,10,11,12,13,14,15]. Among the many causes of death were myocardial infarction, bronchial asthma, cerebrovascular accident, pneumonia and septicemia. Seven patients had an unknown cause of death as their demise occurred outside the hospital with no medical personnel in attendance.

Many factors that were said to contribute to a higher risk for mortality were considered and compared. The first was gender. The general consensus is that males have a higher morbidity and mortality. Our study showed a mortality rate of 40.9% compared with the female rate of 21.5%. However despite an obvious increased rate, they were not statistically significant owing to the small numbers involved.

Age group deaths were compared and showed an 11.76% mortality in the 60-69 age group, 11.11% in the 70-79 years group and 50% death in the above 80 years age group. The increased fragility and osteoporosis could have contributed to the increased mortality in this group. In their study of mortality after hip fractures by White et al[16], they found an inverse relationship between death and the age of the patients. But White et al took into consideration the "standard mortality ratio", which is the ratio between the observed and the expected mortality, adjusted for age and sex. A ratio of more than one represents the degree to which the observed mortality surpasses the expected mortality. It would be with doubt be prudent to take into consideration the expected mortality of the different age groups before drawing conclusions on the observed mortality, however we do not have at our disposal national figures on the mortality of the different age groups for us to make such conclusions.

Although no post-mortem was conducted on any of the patients, the causes of death were based on clinical judgement and assumed to be accurate in most of the cases. Seven patients however had no known cause of death. The various causes of death noted in our study does not fit into any of the predictable causes of death post hip fracture described in literature. However, the lack of scientific evidence on the exact cause of death precludes further comment on the matter.

Delay in surgery was one of the factors that was implicated as responsible for a poorer outcome/higher mortality rate. Surgery being done too soon (less than 24 hours) was also not found to be ideal. The goal was to conduct the operation within two calendar days, during which time it would be possible to optimize the patients for surgery. Our center however was only able to perform surgery in less than 48 hours on one patient. The remaining long period on traction was anything between 3 to 21 days before surgery was performed. When this was compared

between the survivors and those who died by one year, there was no significant difference seen.

There was no statistically significant predictive value in the ASA grading. White et al concluded that it was the most accurate predictor of survival, but it has not been highlighted by other authors.

Although we found more than 50% mortality in the patients who were in the Grade 3 and 4 groups while compared with a mortality of 21.6% from the Grade 1 and 2 groups, this was not shown to be statistically significant.

With regards to associated medical problems, the mortality rates were 22.5%, 29.1%, 31.8% and 0% for patients with zero, one, two and more than three premorbid medical problems. We did not take into consideration the level of control of their medical problems, which perhaps would have been more significant than the number of preexisting morbidities.

Most authors are undivided in their opinions that displaced neck of femur fractures and intertrochanteric fractures have a higher morbidity than undisplaced neck fractures. Our results showed 17.6% mortality of those with Grade 1 and 2; 29% with Grade 3 and 4 fractures; and 30.5% mortality for patients with intertrochanteric fractures - Boyd and Griffith Type 1 and 2. Again these were shown to be statistically insignificant.

The last factor taken into consideration in comparing the survivors and those who died at the end of 1 year was the premorbid Barthel Index. Only a small number of patients had Barthel Scores 16 or less. The outcome in terms of survival was almost identical for the patients with a high premorbid Barthel and lower scores.

Perhaps the best indication of the 'outcome' of the survivors would be the Activity of Daily Living (A.D.L.) Score. Although the Barthel Index is only a basic A.D.L. and fails to take into consideration the extended activities especially outdoor ones, we found the score to be appropriate in our setting. All the patients in our study with the exception of a handful, sustained the fall within the confines of the house. The few exceptions had fallen in the garden or the backyard. Unlike their Western counterparts, the senior citizens in our study were relatively housebound and thus an Extended A.D.L. would not have been very relevant.

As seen earlier, the majority of our patients (>90%) had a premorbid Barthel Score of 17 and above. The decrease in the survivors' functional status was also relatively small, with more than 85% having a score of 15 or more. A score of 12 or less is taken to denote an immobile patient or a poor score. Going by that definition the majority of our survivors had a fair to good outcome. Suffice to say that only one patient was living alone both prefracture and postfracture - and she was a Caucasian.

There were a number of limitations to the study. Firstly the number was small. The duration of the study being one year, the sample size with the innumerable variables made each subgroup statistically too insignificant from which to draw conclusions. A larger sample would however require a much longer period of study; to the tune of 2 - 3 years.

The majority of patients were not followed up in the clinic, thus precluding the opportunity for first-hand examination and A.D.L. scoring. It also denied the opportunity to have radiological evidence of healing for all the patients. One could not thus exclude the possibility of a patient at home who is immobile, actually having an implant failure or a non-union of the fracture causing pain and thus resulting in immobility. History obtained over the telephone could not rule out that possibility. However, the major problem encountered in encouraging the patient to come for follow-up was the lack of transport

and independence (even patients with perfect Barthel scores).

Mental test scores were not done as the patients were from different ethnic groups and had a varied level of education. No test score has yet to be formulated for our population. Hence our results show that the only predictive factor for mortality is age (above 80 years). All other criteria were seen to be statistically insignificant. The second factor to be taken into account is the high mortality rate within the first six months or to be more precise, the first three months post-fall. Accompanying this factor is the lack of deterioration in Barthel score after three months post-fracture. The take home lesson from this is the need to focus all our rehabilitation and medical input energies/resources into the early post-operative phase. This could perhaps marginally improve the mortality incidence and have a significant effect on the functional outcome. Patients would need home visits in the early phase and those found to be slow in walking or regaining their prefracture level of independence, should be referred for assessment by the orthopedist and preferably relevant radiographs taken to rule out implant failure.

Conclusion

Hip fractures in the elderly are a growing problem and aptly termed an 'orthopaedic epidemic'. If not their increasing drain on hospital financial and manpower resources, their sheer numbers will soon awaken the orthopedic fraternity to the magnitude of the problem.

Of the 87 patients whose data was available to us, the majority were Chinese; reflecting the catchment area, and, female; the normal trend. We found a one-year mortality rate of 26 per cent with the majority of the deaths occurring within the first six months (83%). Attempting to look at the common factors among the mortality group, we found no association with medical conditions, ASA grading, different fracture types, duration of hospital stay, delay in surgery or the premorbid Barthel Index. The only predictive factor was the age i.e. those above 80 years of age had a higher death rate post hip fracture.

There was not much change in Barthel score post injury and again no predictive factor could be identified. The only interesting factor was that there was no fall in the Barthel score after the patients returned to their homes. Hence the need for a more concerted effort to improve the quality of perioperative care.

To begin with, a multidisciplinary approach involving the geriatrician, orthopedist, nursing staff, occupational therapist, physiotherapist and the social worker has to combine their efforts to provide this service. The need for the patients' involvement and family commitment cannot be understated. All in, there is a definite need for a 'hip fracture service'. The present practice of including the hip fracture patients with all other closed fracture cases is a gross oversight as the problems associated with hip fractures are obviously unique.

There is a need for a closer follow-up of these patients and a way around the obstacle of these patients being dependent on others for transport. Perhaps the health system should be more supportive of children of patients who need time off for bringing their parents for consultation.

Lastly a larger study with a longer follow-up period needs to be conducted with perhaps more input from a team effort.

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ORIGINAL ARTICLE

Delayed Interlocking Nailing for Open Tibia and Femoral Diaphysis Fractures -A Comparison Between Reamed and Unreamed Nailing

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Summary

The aim of this study was to review the clinical and radiographic results of delayed intramedullary nailing of open femoral and tibia shaft fractures. Eighty-one patients with 84 open fractures of the shaft (43 femoral and 41 tibias) were randomized to interlocking nail with or without reaming. Follow-up information was adequate in 77 patients (80 fractures). These patients were followed up for periods ranging from 8 to 24 months, with a mean of 16 months. There was no significant difference in the union time and deep infection rate between the two groups. However, interlocking nail after reaming has a lower non-union rate ($p = 0.03$, Fisher exact test) and implant failure secondary to non-union, compared to nailing without reaming. Overall, delayed interlocking nailing is a good choice for fixation of open femoral and tibia shaft fracture, up to Grade III B. In this study, it has a union rate of 92.5% and a deep infection rate of 5%.

Key Words: Interlocking nail, Open diaphysis fracture

Introduction

Interlocking intramedullary nailing is the treatment of choice for closed tibia and femoral fractures in adults. High rates of fracture union, a low incidence of complications, and an excellent return of lower limb function have been documented worldwide[1, 2, 3, 4]. Nevertheless, there is still considerable controversy regarding the appropriate role of intramedullary reaming in interlocking nails and whether nails should be inserted as primary immediate or delayed reamed intramedullary stabilization for open tibia and femoral fractures. The standard treatment for these injuries has been external fixation, particularly for fractures associated with more severe soft-tissue injuries[5, 6, 7].

Intramedullary reaming is associated with some loss of endosteal blood supply, higher intramedullary pressure, increased pulmonary artery pressure, and transiently decreased pulmonary function. The damage to the endosteal blood supply caused by reaming[8] may theoretically increase the risks of non-union and deep infection. Hence, it is generally, considered

to be contraindicated in open fractures[9, 10]. Concern about the systemic pulmonary effects of reaming has also led to an increase in the use of nails without reaming. Recent studies have indicated, however, that nailing either with or without reaming can be used for open tibia and femoral fractures with acceptable results [2, 11, 12, 13].

The purpose of this study was to review the clinical and radiographic results of delayed intramedullary nailing of open femoral and tibia shaft fractures after reaming with those of nailing without reaming. Also, it is aimed to compare the early post-operation complications, such as wound infection, compartment syndrome, neuro-vascular injury and fat embolism between the two groups.

Materials and Methods

All adult patients who were admitted to Orthopaedic and Trauma Unit of Ipoh Hospital, a tertiary care hospital, because of an open fracture of the femoral and tibia diaphysis between January 1998 and June 1999 were evaluated for inclusion in this study. The patients gave informed consent before they were entered into the study. All the patients were randomized in selection technique to either nailing with reaming or nailing without reaming. Patients were excluded if they had an open fracture Grade III C and III B which require free flap coverage and fracture with obvious deep infection. Fractures which were judged not to be amenable to interlocking nailing were excluded. This includes fracture in the proximal fourth of the tibia or a fracture within four centimeters of the ankle; fracture in the proximal femur involving the lesser trochanter and within 12cm of the femoral condyle.

Eighty-one patients who had 84 open diaphyseal fractures (43 femur and 41 tibia) were treated. Thirty-seven fractures (18 femur and 19 tibia) were randomized to have a nail inserted after reaming, and 47 fractures (25 femur and 22 tibia) have a nail inserted without reaming.

Follow up was adequate in 77 patients (80 fractures). Follow up was for a minimal period of 4 months. The average age of the 63 male and 14 female patients was 37 years (range, 17 to 80 years). Fifty-four patients were involved in road traffic accidents, 10 had been struck by a motor vehicle as a pedestrian, 7 had sustained the fracture as the result of a fall or a twisting movement during a sports activity, 4 were injured in an industrial accident, and 2 were injured as the result of an assault.

Thirty-six fractures were included in the reamed group and 44 fractures in the unreamed group. With the numbers available, the two groups were not significantly different in terms of average age, gender distribution, and mechanism of injury.

Table I: Comminution of fractures according to Winquist classification

	Reamed	Unreamed
Uncomminuted	4	5
I	12	12
II	9	10
III	7	11
IV	4	6
Total	36	44

The degree of comminution was graded with use of the classification by Winquist and Hansen[14] (Table I). The severity of the open injury was classified according to Gustilo and Anderson [15,16], on the basis of the initial appearance of the wound and the findings during debridement. Fifteen Grade-I, 12 Grade-II, 8 Grade-III A, and 2 Grade-III B fractures were treated with reaming, and 18 Grade-I, 16 Grade-II, 10 Grade-IIIA, and 3 Grade-III B fractures were treated without reaming.

After the initial clinical assessment, all patients were treated with intravenous 1.5 gram of Cefuroxime stat and every eight hours and were given prophylaxis against tetanus, if necessary. Antibiotic therapy was maintained postoperatively for 3 to 5 days, depending on whether there were signs of infection. All of the operative procedures were performed by, or under the direct supervision of two surgeons. A standard operative protocol was followed. Wound debridement was done as emergency as soon as possible. The open wound was either closed primarily or delayed primary closure after 2 to 4 days when there were no signs of infection. Interlocking nailing was performed in the next available Trauma OT.

Ten millimeters hollow nail was used for the reamed group and 9 millimeter solid titanium nail used for the unreamed group. All nails in the study were statically locked with screws in both the proximal and the distal fragments.

The average interval from the time of the injury to the wound debridement was 11 hours (range, 4.5 to 18.0 hours) in the reamed group and 10 hours (range, 5.0 to 16.5 hours) in the unreamed group. Most cases encountered long delay in wound debridement, partly due to the time wasted in transferring patients from the District Hospital and occasionally due to our busy emergency OT.

The median time from the day of the injury to the day of fractures fixation was 7 days for both groups. The range was 3 to 14 days for the reamed group and 2 to 15 days for the unreamed group. Split-thickness skin-grafting was performed for 10 fractures. Three local fascio-cutaneous flap, and 2 gastrocnemius or soleus flaps were used for the Grade-III B tibia fractures.

Early post-operative complications, including wound infection, compartment syndrome, neuro-vascular injury and fat embolism were recorded. These patients stayed in the hospital for a median of nine days (range, 6 to 13 days) in the reamed group and a median of ten days (range, 7 to 29 days) in the unreamed group.

After discharge, we attempted to examine the patients clinically and radio graphically every 4 weeks until union. Clinical union was defined as the ability to bear full weight with no pain at the site of the fracture, and radiographic union was defined as evidence of bridging of three of the four cortices on standard antero-posterior and lateral radiographs. Fractures that needed revision intramedullary nailing or bone grafting in order to heal were designated as non-unions. Implant failure was defined as breakage of screws or nail, when the fracture has not united. A soft-tissue infection was defined as the presence of purulent discharge from the wound with positive bacteriological findings. Deep infection was diagnosed if operative exploration with osseous debridement was needed to eradicate the infection.

The average duration of follow-up was sixteen months (range, 8 to 24 months). Adequate follow-up data were available for thirty-six patients (36 fractures) in the reamed group and for forty-two patients (44 fractures) in the unreamed group.

Comparisons of the average times to union were performed with the Student t test. The prevalence of non-union, deep-infection, implant failure and compartment syndrome were compared between the groups with use of the chi-square test with Yates correction or the Fisher exact test when appropriate; a p value of less than 0.05 was considered significant.

Results

Early Post-operative Complications

Superficial wound infection developed in 1 patient in the reamed group and 2 patients in the unreamed group. All three of these patients had an isolated open tibia fracture. None of the study

Table II: Distribution of cases with non-union

Gustilo's Grade	Reamed Nailing			Unreamed Nailing		
	Femur n=17	Tibia n=19	Total n=36	Femur n=22	Tibia n=22	Total n=44
I	0	0	0	0	0	0
II	0	0	0	1	1	2
III A	0	1*	1	1	1	2
III B	0	0	0	0	1	1
Percentage	2.28			11.36		
P value	0.03					

* Septic non-union of the tibia in the reamed group

Table III: Distribution of cases with deep infection

Gustilo's Grade	Reamed Nailing			Unreamed Nailing		
	Femur n=17	Tibia n=19	Total n=36	Femur n=22	Tibia n=22	Total n=44
I	0	1	1	0	0	0
II	0	0	0	0	1	1
III A	0	1*	1	0	1	1
III B	0	0	0	0	0	0
Percentage	5.56			4.55		

Table IV: Distribution of cases with implant failure

Gustilo's Grade	Reamed Nailing			Unreamed Nailing		
	Femur n=17	Tibia n=19	Total n=36	Femur n=22	Tibia n=22	Total n=44
I	0	0	0	0	0	0
II	0	0	0	0	1	1
III A	0	1	1	0	2	2
III B	0	0	0	0	0	0
Percentage	2.28			6.82		

groups have developed compartment syndrome, fat embolism or neuro-vascular injury as a result of the surgery.

Late Post-operative Complications

1. Non-union

The average time to union was 24 and 20 weeks for the Grade-I fractures in the reamed group and the unreamed group respectively; 24 and 22 weeks for the Grade-II fractures; thirty and thirty-two weeks for the Grade-III A fractures; and twenty-eight and thirty-two weeks for the Grade-III B fractures. With the numbers available for study, the observed differences were not significant.

One fracture in the reamed group and five fractures in the unreamed group did not unite

(Table II) (p = 0.03, Fisher exact test). For the five cases of non-union in the unreamed group, two patients underwent revision with a bigger nail after reaming. Both cases developed union after 16 weeks. Three cases underwent dynamisation alone. Out of the three, one case needed bone grafting in addition to revision of the nail in order for union to be achieved. The non-union case in the reamed group is due to deep infection and will be discussed later.

2. Deep Infection

There were four cases of deep infection. Two developed in the reamed group and two in the unreamed group (Table III). Three cases underwent nail removal, bone curettage and treated with intravenous Cefuroxime. X-ray showed some callus formation and clinically the fractures were stable. One of the cases in the reamed group developed septic non-union. This patient underwent nail removal and an external fixator was applied. Antibiotic-bead was implanted, and the wound was closed at seven days. Bacteriological cultures were positive for Staphylococcus aureus, and the patient was treated with Cloxacillin and Fucidic Acid for 3 months duration, by which time the fracture has united.

Information on non-union and deep infection in Grade IIIA tibia fractures was available for 12 patients in this randomized trial. The overall risk of non-union was 16.7% and deep infection was 16.7%. The use of reamed interlocking nails did not significantly alter the risk of deep infection when compared with unreamed nails. The number of patients is, however, small.

3. Implant Failure

Implant failures occurred in three patients in the unreamed group (6.8 per cent), but none in the reamed group (Table IV). Breakage of screws alone developed in two patients and one patient has broken both the distal screws and the nail at the fracture site. The two cases with screw breakages were associated with a non-union. No specific action was taken, and the breakages did not compromise the outcome. The third case underwent re-insertion of a bigger nail after reaming. The fracture developed union after 16 weeks.

Functional Outcome

Data regarding occupation activity were reported only for the patients who had had an isolated tibia fracture (19 patients in the reamed group and 22 patients in the unreamed group). Fourteen patients (73%) in the group treated with reaming and 13 (59%) in the group treated without reaming had returned to their original occupation. Three patients (15.8%) in the former group and 6 (27%) in the latter had changed occupation as a consequence of the injury. Two patients (10.5%) in the reamed group and 3 (13.6%) in the unreamed group had persistent disability from the injuries and had not returned to any occupation. We could not show these differences to be significant with the Mann-Whitney U test (p = 0.63).

Discussion

The principle of reamed intramedullary nailing in the treatment of closed tibia and femoral fractures has gained widespread acceptance. It has becomes the treatment of choice for long bone shaft fractures[27]. This subsequently has stimulated interest in their use for open fractures. There is a change in open fractures management, from external fixation to an internal osteosynthesis. Whether the medullary canal should be reamed before a nail is placed in an open fracture is a subject of considerable debate. Many surgeons remain skeptical about the value of reaming in the treatment of acute open fractures. Interlocking nail fixation without reaming for open femoral and tibia fractures has shown good results and have gained wide acceptance[13,18,19,20]. But interlocking nailing after reaming remains

controversial. The impairment of vascularisation in regard to bone-healing has gained increasing attention. Previous studies have shown that reaming profoundly disrupts the intramedullary blood supply, which was thought to lead to higher rates of infection and non-union in open fractures.

Locking nailing without reaming causes less damage to the intramedullary blood supply and is considered by some to be a safer method of treatment for open fractures[23,24]. As a consequence, most surgeons embraced the use of small diameter nails inserted without reaming for the treatment of acute open fractures, in the belief that infection rates would be lower. However, recent studies have shown that, although infection rates were lower than those reported in the past, a substantial number of high-energy open tibia fractures treated with small-diameter intramedullary nails without reaming required a secondary procedure to achieve union[25]. Furthermore, failure of interlocking screws was a major problem with this technique. The higher prevalence of delayed union after tibia nailing without reaming may be due to the fact that small-diameter nails do not fill the canal, allowing more motion at the fracture site. The use of a larger nail that fills the canal after reaming may increase the mechanical stability at the fracture site, decrease the risk of breakage of the implant and the screw, and paradoxically lessen the risk of infection.

Williams MM has reported an infection and non-union rate of 2.4% in forty-two acute femoral open fractures which were stabilized with reamed nailing [21]. On the other hand, Kaltenecker reported no infections after treatment of sixty-six Grade-I and II open tibia fractures with nailing after reaming[22]. Court-Brown recently reported a rate of infection of 6% (one of eighteen) for Grade-IIIA fractures and 13% (three of twenty-four) for Grade-IIIB fractures treated with reamed nailing [11,12].

Comparison was made to ascertain whether the process of reaming was related to the rate of clinical complications. With regard to the rates of early post-operative complications, there were no significant differences. The over-all time to union was remarkably similar between the two groups. However there was significant difference in the rate of non-union. One (2.7%) of the fractures treated with reaming and five (11.4%) of the fractures treated without reaming developed non-union.

The over-all rate of deep infection in the current series was low, 5% (4 out of 80 patients). We were unable to show that the reaming process is associated with an increased risk of deep infection. Neither could we demonstrate any difference between reaming and non-reaming. Although theoretically, reaming damages the endosteal circulation, but the overall blood supply to the fracture site does not seem to be reduced significantly. Schemitsch showed a rapid recovery of blood flow to the site of the fracture despite reaming[26]. The success of treatment of open tibia and femoral fractures depends in large part upon the optimal treatment of the associated soft-tissue injury. The viability of the surrounding soft tissue and periosteum helps in the fracture healing. We believe that adequate wound debridement of the soft tissue and bone followed by sound soft-tissue coverage is the key to minimizing deep infection after these injuries, irrespective of whether the bone is reamed or not. We only proceed with the interlocking nailing 3 to 12 days after the injury, when the wound and soft tissue showed no signs of infection. The rate of infection in this series is lower than has been reported by others[11,12]. This may be explained in part by our delayed stabilization of the fractures after initial emergency wound debridement and antibiotic treatment.

The increased prevalence of failure of the locking screws in association with nails inserted without reaming has been noted by other authors[13] but was not associated with an increased risk of non-

union. As might be anticipated, the functional outcomes in the two groups were broadly similar in the present study.

Conclusion

We concluded that delayed interlocking nailing is a good choice of stabilization for open femoral and tibia shaft fracture, up to Grade-III B (Gustilo and Anderson classification). Adequate wound debridement of the soft tissue and bone followed by sound soft-tissue coverage is the key to minimizing deep infection. The overall union rate was 92.5% and the deep infection rate was 5%. There was no incidence of deep infection in all the open femoral fractures in this study. Interlocking nail after reaming gives a higher union rate and lower implant breakage secondary to non-union, compared to nailing without reaming. The early post-operative complications following interlocking nailing were low.

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ORIGINAL ARTICLE

Effectiveness of Sterile Adhesive Plastic Drapes in Controlling Peroperative Microbial Count

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Summary

This prospective, and controlled study is designed to determine the value of self-adhesive sterile plastic drapes in preventing bacteria from entering the surgical wound thus reducing postoperative wound infections. This study was conducted from January 2001 to May 2001, on 50 in-patient volunteers, who were admitted for either elective orthopaedic surgery or with a close fracture waiting for fracture fixation.

Seven skin impressions were taken from the patient's thigh. First before cleaning and draping, second after cleaning with povidone, 3-6th impressions taken from under the drapes at half hour intervals and the 7th at 2 hours from an uncovered area but being cleaned with povidone. There was significantly more growth in the uncovered area (21 of 50 patients) as compared to the covered area (5 of 50) at two hours (p value of 0.001).

Key Words: Sterile adhesive plastic drapes, Postoperative infection

Introduction

Despite advances in aseptic surgical techniques, post-operative wound infection remains at about 2-3%[1] in clean elective surgeries, which is an important cause of morbidity and mortality. It not only results in needless sufferings for countless patients in our hospitals, but it also adds millions of ringgit to the healthcare budget, which has to be borne by the hospital and ultimately by the community at large.

Every surgeon accepts the significance of normal flora of the skin as a source of bacterial contamination leading to surgical wound infections. These infections cannot be eradicated even by various excellent antibacterial agents, which can be administered by any route. They can however only be reduced by adherence to basic strict, principles of antisepsis.

Joseph Lister first preached this principle more than 120 years ago in his dissertation on "Antiseptic principle of practice of surgery" at the annual meeting of British Medical Association[2]. Skin disinfection prior to surgery is now universally accepted as an essential component of

surgical practice[3]. Today more effective products are available for reducing counts of normal skin flora than have been available to the surgeons of the past.

Surgical self-adhesive plastic sterile drapes have been used for more than three decades to protect clean surgical wounds from being invaded by skin flora. Their use however, has been controversial. Several studies have shown their results in favour while others against in reduction of wound infection rates[6,7,8,9,10,11].

Our current study is designed to assess the efficacy of a new self-adhesive sterile plastic surgical drape (FLEXIGRID OpSite Smith and Nephew ®) in controlling or reducing microorganisms in the operating area during surgical procedures.

Materials and Methods

This study was conducted using fifty volunteers who were admitted either for planned elective procedures or those with closed fractures awaiting fracture fixation. Informed consent was obtained from them. Strict and meticulous criteria were adhered to in the patient selection. They were:

Inclusion Criteria
Individuals who were admitted for either elective procedures or with post-traumatic close fracture and agreed to participate in this study.

Exclusion Criteria
The exclusion criteria were Chronic ill, immunocompromised and bed-ridden patients, those with hospital stay of more then 3 days and all the infected or potentially infected cases.

Patients with known allergies to povidone iodine and with skin problems such as boils, laceration wounds or abrasions were also excluded from the study.

We conducted our study in a clean, isolated room in one of our recently renovated wards, which was used for only this study for that specific time period. The room was air-conditioned and had scrubbing facilities.

The skin impressions were taken using the contact plate after removing its covering lid and then placing it inverted, with the agar side on the skin. The contact plate was held for five seconds. The gel like culture media slides down and comes into total contact with the patient's skin.

Seven impressions were taken from the patient's thigh. The first impression with the contact plate labeled as No.1 was taken from the skin of the thigh before it was cleaned and draped. This shows the normal flora present on the patient's thigh.

Next the author scrubbed using hibitane solution, donned a sterile disposable gown and wore a sterile glove using sterile aseptic methods. The patient's thigh was thoroughly cleaned with povidone iodine from groin up to well below knee, followed by draping with disposable self-adhesive drapes.

The second impression was taken with contact plate labeled as No.2 after cleaning and draping the patient's thigh. Then two sterile plastic drapes measuring 10cm x 12cm were applied simultaneously over patient's thigh after 3 to 5 minutes once the povidone was dry.

After half an hour interval half of the one sterile self-adhesive drape was being lifted from the skin and an impression was taken from this area. This was labeled as No:3. In the same way the other half of this drape one was lifted up from the skin and 4th impressions was taken.

5th and 6th impressions were taken from under the second drape in the same manner, and were labeled accordingly. Thus the 3rd impression was

taken at half an hour and the 6th impression was taken at 2 hours from the application of the drapes. In between each contact plate, the author changed another pair of sterile gloves, as the contact plates were not sterile from outside.

A final impression (7th impression) was taken simultaneous with the 6th impression however from an area of skin not covered by the sterile plastic drapes, though it was earlier cleaned with povidone. This contact plate is labeled No.7 and it acts as a control for the study.

All seven contact plates were collected and immediately sent to the microbiology laboratory for both culture and sensitivity. These samples were then incubated aerobically at 35°C for 18-24 hours. Colony counts were performed after 18 to 24 hours and the organisms identified using standard microbiological techniques.

The results were analyzed with Statistical Packages for the Social Sciences (SPSS) 9.05 version. The statistical analyses were done using Chi-Squared test (Yates corrected) and the statistical significance defined as $p<0.01$.

Table I: Details of patients who participated in the study

Orthopaedic Discipline	Number
Trauma	19
Joint Replacements	10
Spine	7
Sports	8
Hand	6
TOTAL	**50**

Table II: Showing the normal skin flora from the first impression

Organism	Number
Staphlococus. Epidermidis	42
Staphlococus Aureus	3
Acinobacter SPP.	6
Neisseria SPP.	8
Micrococcus SPP.	28
Bacillus SPP.	13
TOTAL	**100**

Table III: Showing details of impressions taken and growth yielded

Impression	Time	Povidone	Opsite	Growth(A)	Contamination(B)	YEILD OBTAINED (A-B)
1ST	0:00	NO	NO	50	0	50
2ND	0:00	YES	NO	0	0	0
3RD	0:30	YES	YES	0	0	0
4TH	0:60	YES	YES	2	2	0
5TH	1:30	YES	YES	6	3	3
6TH	2:00	YES	YES	10	5	**5***
7TH	2:00	YES	NO	27	6	**21***

(*Chi-squared test with a p-values = 0.001).

Results

There were thirty males and twenty females. Their age ranged from 20 to 65 years with a mean age of 36.7 years. They were admitted under various orthopaedic disciplines (Table I) however most of the patients were awaiting fixations of closed fracture (19 patients).

The first impression was taken before the thigh was cleaned and draped and this represents the normal skin flora. There was 100% growth and Table II illustrates the frequency of the various organisms.

The second impression reflects the growth, which was obtained from skin immediately after cleaning with povidone iodine. In all 50 impressions there were no growth (Table III). The third impression taken from under the sterile plastic drape at 30 minutes also grew no organisms. The fourth impression taken at 1 hour grew fungal organisms in two patients and the same organisms were isolated from the contact plate left exposed in the room environment (Plate 1A). These were considered to be contaminations thus were excluded. In the fifth impression there were 3 true growths while 3 contaminations from the atmosphere. There were 5 and 21 true growths in the 6th and 7th impressions, with 5 and 6 contaminations respectively.

With the passage of time there is an increasing trend in growth of organism, from 4th to 7th impression (Chi square test for linear trend, p-value = 0.00376). When the 6th impression was compared with the control (7th impression) there was significantly more growth yielded (Chi-square test with a p-value = 0.001).

Discussion

A variety of techniques are used to prevent bacteria from entering the surgical wound. However the microorganisms harbored on patient's own skin are particularly troublesome. The structure of skin makes it virtually impossible to maintain it sterile throughout any surgical procedure.

The important role of the patient's skin organisms in postoperative wound infections has long been recognized. Kin Month et al[4] found hospital staphylococcus in 10% of patients they studied. In another study by Maxwell et al[5] showed that 10% of the patients still had unsterile skin after a thorough skin preoperative preparation. This is expected since the microbes harbor in the crevices of the skin, deep down in the hair follicles, sweat glands and sebaceous glands, therefore it is impossible to make the skin sterile or maintain it sterile during surgery by an antiseptic solution.

Although we are able to eradicate the normal skin flora with the use of povidone iodine as in this study, with the passage of time the bacteria harbored in the hair follicles invariably rise to the surface, thus contaminating the area previously cleaned and draped. The function of the sterile plastic self-adhesive drapes is to immobilize these bacteria arising from the deeper crevices of skin and hair follicles, thus providing a physical barrier to these microorganisms. These drapes do not allow bacterial lateral migration underneath them.

This study has shown that sterile plastic drapes are effective in preventing bacteria multiplication beneath them at 2 hours as compared to control. (P value = 0.001). Similar studies in the literature however provide conflicting results. Some investigators like Shephard et al[6], Maxwell et al[7] and French et al[8] showed that the plastic drapes were very useful in reducing the postoperative skin infection. However other investigators like Lilly et al[9], Jackson et al[10] and Cruse et al[11] have found them not to be useful.

The reason for this controversy lies in the fact that there are many sources of contaminating organisms, which may contribute to wound sepsis, and it is impossible to control all the

variables in individual patients. Another shortcoming in the use of these drapes has been the occasional seepage of blood and wound irrigation fluids beneath the drape due to poor drape application.

Besides acting as a physical barrier, the plastic drapes also helps keeping the linen drapes in place hence minimizing the use of towel clips. They also keep the operative area clean and the linen drapes dry after wash and spillage of body fluids. This also further contribute in reducing postoperative wound infections, as studies has shown that wet linen drapes showed profuse bacterial penetration as compared to dry ones. It also helps in preventing loop decubitis by suturing the wound along with the drape.

This study was conducted in a clean room in the ward. It would have been ideal if this was done in the operating theater. However as stated earlier this room was clean with central air conditioning. This room was also used only for purpose of the study during the designated time period. We believe we have eliminated the possibility of airborne contamination by using the contact plate 1A, which was left exposed in the room environment.

Conclusion

This study has shown that there is no lateral migration of bacteria; as well they do not multiply under the sterile plastic drapes after 2 hours. As it is quite clear from the above result that these plastic sterile adhesive drapes play an important role in controlling peroperative microbial counts besides its aesthetic values, hence reducing postoperative wound infection rates.

I strongly recommend these sterile self-adhesive plastic drapes for any surgical procedure with more than one hour of operating time.

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ORIGINAL ARTICLE

Patterns in Osteoporotic Spine Fractures

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Summary

In osteoporotic spines, the thoracic and lumbar segments are particularly prone to compression fractures. Most authors record varying incidences of involvement in the thoracic, lumbar and thoracolumbar regions with very rare instances of neurological loss. We conducted a cross-sectional study to investigate which segment was more frequently affected, pooling 111 patients of all races aged 60 years and above presenting with atraumatic backache from 1995 till 2001. None had received previous treatment for osteoporosis. Malignancies and other spinal pathologies were excluded. We studied timing and modalities of diagnosis. Our study revealed a predominance of thoracolumbar injuries in osteoporotic spine fractures and highlighted the possibility of neurological consequences in these low-energy events. Local anatomic and trabecular patterns may be implicated. In at-risk patients presenting with atraumatic backache, appropriate attention must be given to the thoracolumbar spine region.

Key Words: Atraumatic backache, Osteoporotic spine, Compression fractures

Introduction

The spine is classically affected in osteoporosis, with vertebral fractures that affect both men and women. Besides being a source of significant local morbidity and decreased quality of life, osteoporotic vertebral fractures may also portend susceptibility to limb fractures[1, 2, 3].

Frequently occurring without any history of trauma and often with little accompanying pain, osteoporotic spine fractures may occasionally pose problems in diagnosis - recognised only later when multiple contiguous vertebral segments have kyphosed into a dowager hump. Knowing which part of the spine is more commonly involved could help in enhancing the physician's index of suspicion.

Existing literature show little concurrence among researchers on the vertebral segments most commonly fractured. Working retrospectively, we studied local figures at the Department of Orthopaedics and Traumatology, Hospital Pulau Pinang.

Materials and Methods

Our series of 111 adult patients was pooled from the Orthopaedic Outpatient Clinic from 1995 - 2001. We only selected patients who presented with backache but without any history of significant trauma, defined here as any physical injury that caused disturbing pain, visible bruising, dysfunction or deformity. Ethnically diverse, all were aged 60 years and above. This

age group comfortably includes both post-menopausal as well as senile osteoporosis, the two common causative factors[4, 5]. To accurately present the natural history of the disease, we excluded patients who had received anti-osteoporotic treatment before. To remove confounding factors, patients with wholly different pathologies like malignancies and backache of other origins were not included.

We studied clinical records, admission files and spine radiographs. Attention was given to determining the spinal levels involved and the modality first employed to successfully diagnose the lesion - whether through history-taking, clinical examination or radiographs - granting that radiographs were the final determining and most accurate modality.

Results

There were 21 male and 90 female patients with a total of 167 vertebral fractures. Ethnically, there were 16 Chinese, 4 Malay and 1 Indian men. Seventy-eight Chinese, 10 Malays and 2 Indians were female (Table I).

Table I: Ethnic and gender composition

	Malay	Chinese	Indian
Male	4	16	1
Female	10	78	2
Total	**14**	**94**	**3**

Table II: The distribution of vertebral involvement

T_4	3 (1.8%)
T_5	6 (3.6%)
T_9	1 (0.6%)
T_{10}	5 (2.9%)
T_{11}	10 (5.9%)
T_{12}	29 (17.4%)
L_1	60 (31.1%)
L_2	21 (12.7%)
L_3	10 (5.9%)
L_4	13 (7.8%)
L_5	9 (5.4%)

Table III: The distribution of cases with neurological deficits

Level	Number of cases
T^{11}	1
L^1	4
L^2	1

Table IV: The first diagnostic modality successfully employed, relative to the number of visits necessary to secure the diagnosis

	1st Visit	2nd Visit	3rd Visit	4th Visit
History	21	-	-	1
Clinical Examination	68	3	1	1
Radiographs	90	-	-	-
Repeat radiographs	1	5	1	3

Fifteen male patients were found to be using steroids for treating chronic obstructive airway disease, compared to 4 females.

The single most frequently affected vertebra was L_1 with 60 (31.1%) cases followed by T_{12} with 29 (17.4%) and L_2 with 21 (12.7%). Collectively, the thoracolumbar segments of T_{10} to L_2 were involved 125 times (74.8%). Above T_{10}, the only thoracic lesions observed were 3 of T_4, 6 of T_5 and 1 of T_9 (Table II). Neurological sequelae afflicted 6 patients; in 4 cases of L_1 injuries and 1 each of T_{11} and L_2 (Table III). Two L_1 fractures suffered cauda equina lesions.

Ninety-one patients had their spine fractures detected on the first clinic visit, employing one pair of radiographs (anteroposterior and lateral). In 10 patients, fractures were diagnosed only after a second series of radiographs on subsequent visits (Table IV).

Discussion

The pathology behind osteoporosis has been the subject of intense study. There is a clear

consensus among contemporary researchers that this affects both women and men, bringing much morbidity and often hastening mortality[4, 5, 6].

The ethnic pattern seen in our result reflected the racial make-up of the local populace in Georgetown city. More important was the frequency of steroid therapy to combat chronic obstructive airway disease in our male patients. This mode of secondary osteoporosis shows a correlation to corticosteroids that has been highlighted by many other studies[7, 8].

A literature search shows there has been no agreement on which spine region is most vulnerable. The lumbar vertebrae have been implicated by virtue of possessing higher trabecular bone stock. This contrasts with an earlier study suggesting thoracic predilection, explained theoretically by the action of biomechanical forces. Others felt there was equal incidence in the thoracic, thoracolumbar and lumbar spines[9,10,11]. The dominance of thoracolumbar involvement in our series was represented mainly in the 1st lumbar and 12th thoracic segments, followed in frequency by the 2nd lumbar, 3rd lumbar and 11th thoracic vertebrae. This region, the confluence of a relatively rigid thoracic spine and a mobile lumbar, experiences a high concentration of stresses loaded when maintaining an erect posture and therefore may explain its susceptibility[12].

Ten patients had their fractures diagnosed only on a subsequent visit employing a second or third set of radiographs. In four cases, no initial imaging was ordered and subsequent ones were directed towards the lumbosacral region, missing the thoracolumbar junction. Three of the 10 patients were detected to have fractures only on the 4th visit that occurred 6 weeks after trauma. Radiographs were concordant with the projected timeline and showed bony callus formation with sclerosis. There is a need to heighten physician awareness of the problem, as history-taking provided the diagnosis in only 21 cases. This was offset by many doctors prescribing radiographs on the first visit to have a definitive assessment.

Underdiagnosis of spine osteoporotic lesions is a common problem[13,14,15]. Physician-related causes are compounded by a medical history misleadingly devoid of trauma. Referred pain along the back also confuses the elderly patient's ability to pinpoint correct levels. Backache of other origin like discogenic or facetogenic lesions further complicates the picture - a situation we recognised as an exclusion factor in our study.

Conclusion

Although our series is modestly sized, we have shown a dominance of thoracolumbar involvement in osteoporotic spine fractures. Our findings also suggest that where history reveals nothing, further clinical examination may unveil local tenderness and deformity. A fiat to radiograph all backache would deter cost-effectiveness but radiographs of the suspect spine, when prescribed, should include the thoracolumbar region. These may help in the timely diagnosis of such lesions.

We feel it prudent to expand our sample size by adding multi-centric involvement and extending our local data collection. Osteoporosis being age- and gender-sensitive, correction factors would be most appropriate when applied to the final data.

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CASE REPORT

Shepherd's Crook Deformity Following a Subtrochanteric Fracture

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Summary

Neglected and malunited fracture is not uncommon problem in our society. Severe deformity of neglected fracture of the hip can be misleading. We want to highlight clinical features, radiological findings and management of a rare complication of subtrochanteric fracture which mimicking a Shepherd's crook deformity with one stage double osteotomies and nailing.

Key Words: Subtrochanteric fracture, Shepherd's Crook deformity, One stage osteotomy

Case Report

A nine-year-old girl presented to orthopaedic clinic of University Science Hospital with a problem of limping due to severe shortening of her left lower extremity two years after she sustained a closed subtrochanteric fracture of left femur with head injury in a road traffic accident.

Clinically she had a significant short-legged limp gait with toe in of the left foot. There was a lateral bowing of proximal thigh with left lower limb attitude held in 30° internal rotation. She had 5cm shortening, mainly in the thigh. Left hips flexion and extension was comparable to normal side, but abduction is limited to 10° and increased adduction to 40°. She had a significant fixed internal rotation deformity of 30° - 80°. Nevertheless, she was a healthy girl with no clinical evidence of osteogenesis imperfecta and metabolic bone disease or suspicious skin stigmata.

Antero-posterior radiograph of the pelvis showed a severe varus of "Shepherd's crook" deformity of the proximal femur. Rotational deformity was marked as indicated by changes of lesser trochanter. Blood investigation namely; serum calcium, alkaline phosphatase and renal profile were within normal value.

Single stage double osteotomy of proximal femur to correct shortening and deformity was performed. We managed to achieve 4cm lengthening and correct coronal, sagital and rotational deformities. The corrective osteotomies were maintained with an intramedullary rush rod nail fixation and lower limbs were stabilised in one and half hip spica cast for six weeks. Currently after twenty -four months of surgery, she is able to walk with a mild limp and can perform squatting. At last visit, her left lower limb was 1cm shortened with almost full range of left hip motion and rotation.

Discussion

Neglected and fracture malunion is not uncommon problem in our society. Severe deformity of a neglected fracture of the hip can be misleading. Severe varus deformity of the proximal femur and remodeling of the bone can mimic Shepherd's crook deformity as seen in fibrous dysplasia and progressive deformity of metabolic bone disease or osteogenesis imperfecta. However additional rotational deformity as demonstrated in this case was strongly suggestive of previous fractures as deformity due to other pathology usually in sagital or coronal plane.

Shortening is common following malunited femoral fracture. Sagital or coronal plane deformities, as well as rotational malalignment are frequent, and the choice of treatment for such complex deformities may be difficult[1]. The decision for operation must be based on patient's symptoms and age, the relative shortening and deformities as well as the stage of fracture healing. Shortening of other limb may be appropriate in growing children but this procedure does not deal with deformities in the injured leg. Both shortening and deformity can be corrected by gradual distraction osteogenesis in an external fixation frame[2]. These progressive procedures can produce dramatic increase in length but have prolonged healing time and many complications[2].

One stage femoral lengthening is thought to have an acceptable high complication rate and is not widely practiced. These surgeries usually involved major soft tissue dissection with powerful traction and caused significant incidence of major complication including sciatic and femoral nerve palsies, arterial occlusion and infection[3]. However with minimal soft tissue dissection, deformities and shortening of mean 4cm can be corrected without major neurovascular complication[1]. With minimal soft tissue dissection of bone, careful soft tissue handling and gradual distraction of bone, shortening and deformities can be corrected in one stage as illustrated by our case.

Planning of surgery and osteotomy is crucial, as all components of deformities must be corrected in single stage. Ideally, the osteotomy should be at the site of maximum deformity; however, due to long segment deformity osteotomy was done at two levels to overcome all the deformities. We used Rush nail intramedullary fixation as medullary canal is small in children and corrected rotational deformity can be stabilized in hip spica cast.

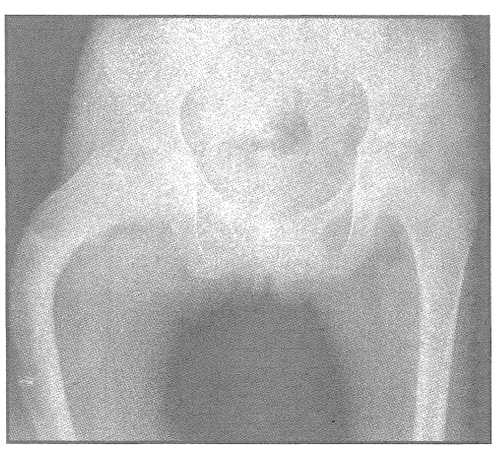

Figure 1: Anteroposterior radiograph showed a Shepherd's Crook deformity of left proximal femur following a subtrochanteric fracture

Figure 2: Widened view of the deformity

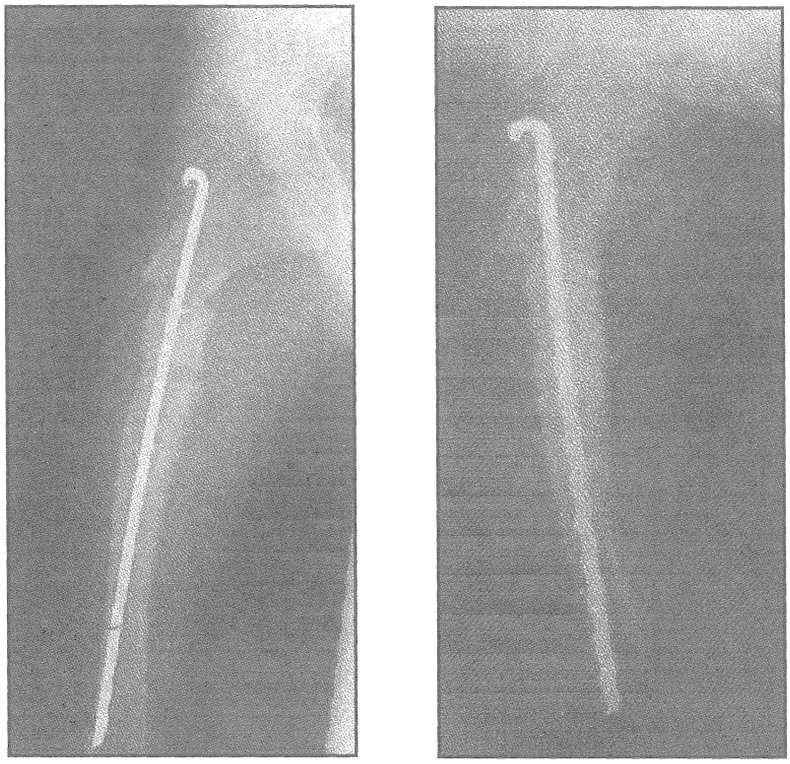

Figure 3: The deformity was corrected with a double osteotomies and stabilised with a rush nail

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CASE REPORT

A Rare Case of Li Fraumeni Syndrome Cancer Family Syndrome

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Summary

A 26-year old female presented with osteosarcoma of the rib. Three years later, her 16-year old brother developed osteosarcoma of the right tibia.

They belong to a family with a strong history of various types of cancers. The disease pattern is similar to a rare familial cancer disorder known as Li Fraumeni Syndrome. To the best of our knowledge this is the first reported family with Li Fraumeni Syndrome in Malaysia.

Key Words: Li Fraumeni syndrome, Osteosarcoma

Introduction

There is much interest in the study of genetic susceptibility to cancer. Historically there are several clearly defined cancer family syndromes, including Puertz Juerger Syndrome, Neurofibromatosis and Polyposis Coli. Li-Fraumeni Syndrome (LFS) was first described, by Li FP and Fraumeni JF. In 1969[1]. It is an inherited form of cancer, affecting children and young adults, and characterized by a wide spectrum of tumours, including soft tissue and bone sarcomas, brain tumours, adrenocortical tumours and premenopausal breast cancers. This syndrome is rare compared to the other types of cancer family syndromes. We report two siblings who presented with osteosarcoma from a family with a strong history of various malignancies.

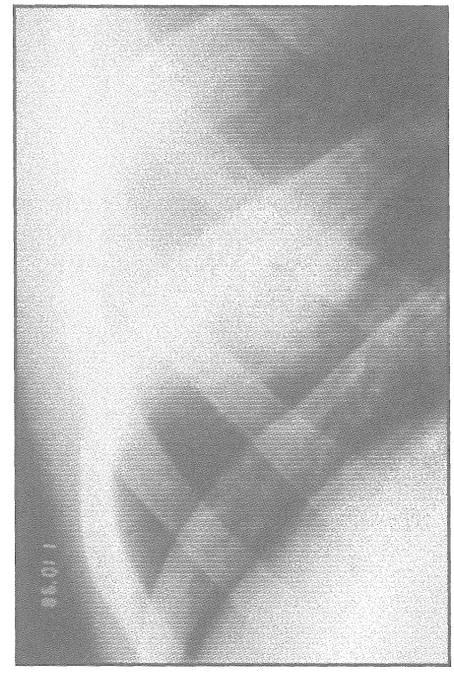


Figure 1: Osteosarcoma of the rib

Case 1

A 26-year old Chinese girl developed swelling of her right lateral chest wall for 2 months. This was associated with pain and weight loss. There was no history of cough or haemoptysis. Radiographs showed an osteoblastic lesion of the right 7th rib (Figure 1). An open biopsy confirmed the diagnosis of osteosarcoma. There was no evidence of metastasis on the CT Scan of the chest. She was given neoadjuvant chemotherapy followed by wide resection of a segment of the 7th rib. Postoperatively another 3 courses of chemotherapy were delivered. She is disease free on last review three years after surgery.

Figure 2a: Periosteal osteosarcoma of the tibia

Case 2

A 16-year-old Chinese boy who is the younger sibling of the Case 1 presented with a progressively enlarging swelling of the upper right tibia for 4 months duration. This was associated with moderate pain with no fever, weight loss or loss of appetite.

X-ray of the affected tibia showed an osteoblastic lesion of the diaphyseal region (Figure 2a). Presence of Codman's triangle and sun burst appearance of the lesion suggested osteosarcoma and it was confirmed by a needle biopsy. CT Scan of the chest showed no pulmonary metastasis.

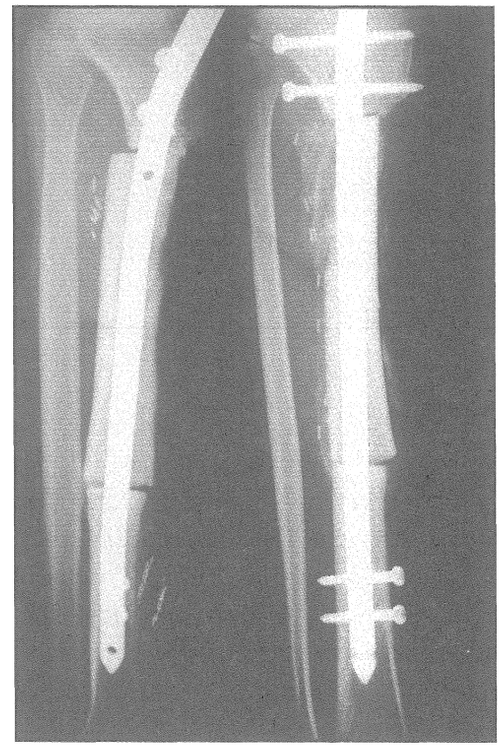
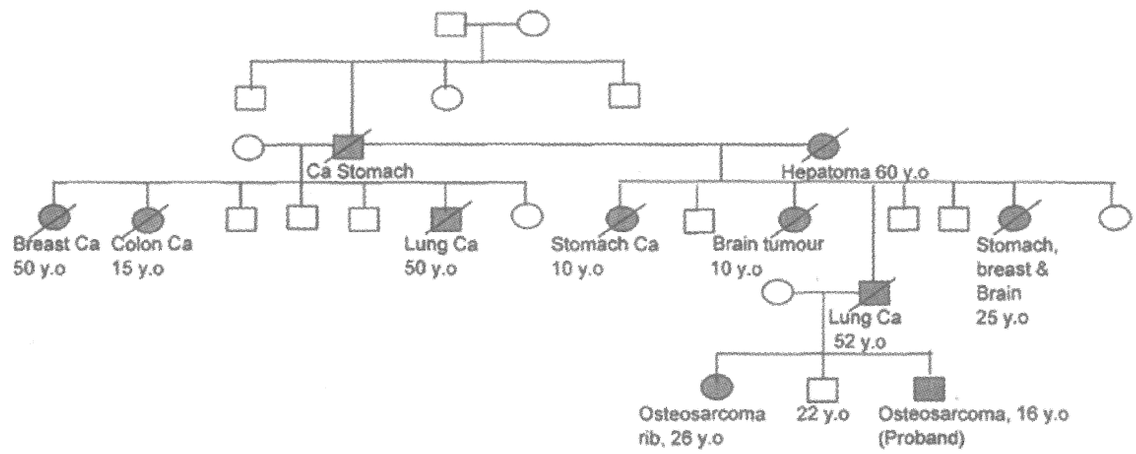


Figure 2b: Post-operative xray with allograft and nailing

Wide excision of the tumour was performed after 3 courses of neoadjuvant chemotherapy. The bone deficit was reconstructed with an intercalary allograft stabilised by interlocking nail fixation (Figure 2b).

Post-operative period was uneventful and he completed the chemotherapy regime. The boy returned to the institution about 6 months after surgery for sudden onset of left-sided weakness. MRI revealed a large brain tumour which is likely to be of primary origin. The family refused further intervention and decided to seek traditional treatment.

Figure 3: Family tree of patient



Discussion

In 1969 Li and Fraumeni described 5 families among a group of 648 children with rhabdomyosarcoma[2]. They noted that within these families there was a high risk of premenopausal breast cancer and second malignancy. The pattern of inheritance was most likely to be autosomal dominant. The diagnostic criteria for this syndrome includes[2]:

1. A proband aged under 45 years with a sarcoma, with a;
2. First degree relative aged under 45 years with any cancer and additional;
3. First or second-degree relative under 45 years with any cancer or sarcoma at any age.

Types of tumour in LFS spectrum include acute leukaemia, premenopausal breast cancer, brain and adrenocortical tumours as well as bone and soft tissue sarcomas[2]. Other studies have indicated that a number of other cancers may occur at an increased frequency in these families, notably melanoma, germ cell tumours, Wilms` tumours, gastric and pancreatic carcinomas and lung cancer[3].

Although the diagnostic criteria of this syndrome are well accepted, other researchers feel that it is too stringent. They suggest a more relaxed diagnostic criterion and coined the term Li-Fraumeni Like Syndrome[2] (LFL). The diagnostic criteria includes:

1. Proband with any childhood tumour or sarcoma, brain tumour or adrenocortical tumour under 45 years, plus
2. First or second degree relative with a typical LFS tumour at any age and another first or second degree relative with any cancer under the age of 60.

Germline mutations of tumour suppressor TP53 gene were thought to be the main underlying factor to develop LFS. Porter et al reported on 17 patients with osteosarcoma and found two families, which fulfilled the diagnostic criteria for LFS. Both these families were shown to have the genetic alteration in the TP53 gene. Li et al[2] reported that 71% of patients with LFS had TP53 mutations. The TP53 encodes a transcriptional factor able to regulate cell cycle and apoptosis when DNA damage occurs. TP53 gene will halt the cell cycle in the G1- synthesis interface and

allow the DNA repair to take place. If the damage is irreparable TP53 will then initiate apoptosis.

The two siblings described in this report fulfilled the criteria needed for the diagnosis of LFS[2]. There is a first degree relative under the age of 45 with a sarcoma and multiple second-degree relatives with various types of carcinomas and sarcomas (Figure 3).

Four out of 15 siblings of the patient's father had died below 45 years of age. Three others including father of the proband developed cancers in their fifties. It is interesting to note that those who developed cancers after the age of 50 years were all male while those with cancers below the age of 45 years were female with the exception of the proband. The pattern of transmission suggests an autosomal dominant inheritancy as suggested in the literature. There seems to be a later clinical manifestation of cancer in males as compared to females. Although it is difficult to exclude incidental cancer in older members of the family, it is obvious that the father of the proband did transmit the condition to his offspring although his manifestation of cancer was at 52 years of age. Unfortunately we do not have any facilities to analyse the genetic components at this stage.

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LETTER TO EDITOR

Infection in Total Knee Replacement Surgery

Orthopaedic Supplement D
MJM Vol 56 December 2001

Sir – The authors of "Risk Factors for Infection in Total Knee Replacement Surgery at Hospital Kuala Lumpur", A B Sharizal, et al, (Orthopaedic Supplement, Med J Malaysia; 56(D): 5-8) must be commended on an honest, fascinating and frightening paper. They reported a retrospective review of 100 primary TKRs between 1994 and 1999 and reported a superficial infection rate of 2% and a shocking deep infection rate of 9%.

A recent paper from the Hospital for Special Surgery in New York retrospectively reviewed 6489 primary and revision total knee replacements and reported overall incidence of surgically acquired or early deep infection rate for primary total knee replacement patients was 0.39%. For revision patients, the rate was 0.97%. (PeersmanG, Laskin R, Davis J, Peterson M. Infection in total knee replacement: a retrospective review of 6489 total knee replacements. Clin Orthop. 2001; 392: 15-23).

The difference in results, a 23-times higher deep infection rate, even accounting for the different criteria for early and late infection, suggest that we have a lot to do yet if we are to match world standards for this very major procedure.

In fact, more studies should be done by all the academic centres in Malaysia that do such surgery, to confirm whether our results in Malaysia are really so appalling. If so, we, as an orthopaedic community, must question if we should in fact continue to perform this surgery, and thereby maim almost 10% of our patients! (And please note that this comment comes from a self-professed knee surgeon!). At the very least, such surgery must be limited to appropriately trained and supervised surgeons, and in an appropriate operating environments. We may need to insist on the building of ultra-clean operating theatres in Malaysia.

S Gobinder, FRCS, Consultant Orthopaedic Surgeon, Pantai Medical Centre, Jalan Bukit Pantai, 59100 Kuala Lumpur

Author's Reply

Sir – We thank Dr S Gobinder for his comments. We agree with him that the infection rate in our study is high. Dr S Gobinder has quoted Peersman et al's work of 2001 from the Hospital for Special Surgery in New York and the University Hospital of Antwerp, Edegem, Belgium; in which an infection rate of 0.39% in Primary TKR and 0.97% in revision TKR in a series of 6,489 knees were reported (overall infection rate of 0.43%).

Peersman has described that his study was in patients who had surgery in OR's equipped with vertical laminar flow units and 15 air exchanges per hour to the Operating Room. Furthermore, the pre-filters were replaced monthly and after

filters were replaced at least twice annually. The staff used water repellent paper gowns, drapes and body exhaust suits. The operating room temperature was maintained within a range of 65 to 72 degrees F with a relative humidity of 50%. He also reports that patients without an infection had a mean operative time of 93 minutes; while patients with an infection had a mean operating time of 127 minutes. Peersman concludes, quite rightly too; that his infection rates are the lowest ever reported so far. He however, makes a point that this low rate was achieved chiefly by the combination of surgeon isolated in a body exhaust suit and vertical laminar flow.

There are several key differences in Peersman's practice and our series. Our series had serious shortcomings. Among others, OT environment (non dedicated general Orthopaedic OT's), length of intra-operative time, post-operative care in general Orthopaedic wards, length of post operative stay (in general orthopaedic wards), variable surgeon training and experience, patient selection (high proportion of diabetics); and perhaps the most significant - data collection (the best being from a prospective study-our rate may still represent under reporting!).

Nevertheless, we do agree with Dr S Gobinder on his two points; this should be a plea for the construction of dedicated, laminar flow equipped OT's for at least knee replacement surgery, and that there should be publication/declaration of the infection rates of all hospitals which offer this surgery. This is in the interest of the patients, who must be made aware of the risks of the possible complications including infections as part of a proper material risk disclosure consent.

S Harwant (Senior Author and Project Supervisor of AB Syahrizal)

LETTER TO EDITOR

Orthopaedic Supplement D
MJM Vol 56 December 2001

Sir – I feel impelled to commend on the Editorial and Editor's Note of the Orthopaedic Supplement of the MJM December 2001. There is a satisfactory sense of optimism in both articles about the present numbers of Orthopaedic Surgeons in the country. However, this is merely an undifferentiated quantitative viewpoint as far as services to the whole society is concerned. Although the Editor's note made an attempt at classifying the location of these surgeons, it fell short of exactly quantifying the resources in both the public and private domains. It is an established paradoxical reality in this country that most of the specialists are in the private sector as compared to patients who predominantly attend the public hospital [1]. This inequitability (mismatch) of resources and services of clinical services is a matter of serious importance to all concerned. For the society on the whole to reap the fruits of the knowledge and experience gained from the efforts by our scientists and researchers, there must be in place an equitable health system for appropriate disbursement of resources.

A cursory observation shows that a critical mass of specialist/consultants and lectures quitted public services even before reaching the peak of their potentiality leaving a scenario of hierarchical gap in medical human resources. This uneven hierarchical system has bearing on the transmission of clinical knowledge and expertise, for generations gap do affect communication and relationship [2]. This results in a phenomenon whereby services were perpetually run by juniors for there is lack of hierarchical continuity in the system. In order to ensure this hierarchical continuity, there must be in place a system of staff retention, attractive enough to pull the most talented and academically inclined of each generation of clinicians to remain in the public system where most of the required services and researchers take place.

Although I share with the authors enthusiasm with regard to our standing now as compared to the past, in Orthopaedic surgery like any other clinical disciplines especially surgical in nature, the overall gain in the quantity of surgeons from the existing training system is not appropriately matched with the equally important qualitative impact on the society on the whole with regard to good services. There must be a socially equitable system that will ensure both aspects of clinical services to be sustainable. Perhaps the well defined dichotomous separation of public and private medical sectors should be significantly altered and made flexible in order to adjust the human resources to match the service needs of the public more appropriately. This, together with professional appointment of consultants rather than administrative promotion and other reasonable socioeconomic strategies may be important steps towards creating a strong fundamental in human resource management in our health service which is deemed the most important factor to ensure

good quality service and research in a highly globalized world [3].

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3. Suleiman AB et al. Research Priorities: Future Challenges. Med J Mal Mar 2000 (Editorial)

Author's Reply

Sir – Thank you for your interest in the Editorial and Editors note of the December 2001 issue of the Orthopaedic Supplement of the Medical Journal of Malaysia.

We agree with your views regarding the differences between the public and private medical services.

However, the aim of the editorial and the editors note is to highlight the progress over the last 20 years in the MS Orth programme and the legacy of Orthopaedic research in Malaysia and its future directions.

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