Consensus document

The Bone and Joint Decade 2000–2010

Inaugural Meeting 17 and 18 April 1998, Lund, Sweden

The increasing impact of bone and joint disorders on patients and healthcare systems, and an awareness that resources need to be more efficiently used, led to arrangements for a Consensus Meeting. This was held in Sweden in April 1998 and ended in an agreement to launch a Decade of Bone and Joint from 2000 to 2010.

The aims of the Decade will be to raise awareness of the suffering and cost to society of musculoskeletal disorders such as joint diseases, osteoporosis, spinal disorders and severe trauma, and encourage research and development throughout the world.

Opening address

Around the world, health care systems face increasing pressures from rising demand and escalating costs. All governments are looking for innovative ways of limiting the growth of health care budgets. Interest groups in specific disease areas recognise that additional funding and avoiding cuts must be justified by economic data which show that it is cost effective to spend money in their particular area.

Musculoskeletal conditions are among the most common medical conditions with a substantial influence on health, quality of life and the use of resources. Medicine, more and more based on sophisticated technology, is becoming very expensive. At the same time the world population is ageing. In Europe by 2010, for the first time, there will be more people over 60 years of age than under 20 years, and by 2020 the elderly will represent 25% of the population. How can we deal with such a situation?

The answer probably lies in developing medical programmes with agreed guidelines, and to achieve this research has a key role. Only firm data can provide an objective base for such guidelines.

Musculoskeletal disorders or injuries will affect almost every individual at one time or another in their lifetime. Some conditions are minor and transient, but many cause lifelong disability.

The impact of bone and joint disorders on society, the health care system and on individual patients, and the awareness that resources must be used more efficiently, led to the initial *proposal for a Decade of Bone and Joint*. This inaugural meeting was planned to show the needs, and to point to possible improvements in prevention and treatment during the coming decade.

Four important areas were selected by the organizing committee as examples to allow more detailed consideration and recommendations. These are joint diseases, spinal disorders, osteoporosis and trauma.

One objective was to identify the priority areas most needing work during the first decade of the next millennium. Working groups are to identify the extent of the problems, the impact on society, and the needs for future research in each field.

During the first day, selected experts will give their views on these four topics, and non-expert and independent panel members will then discuss them. Each group will be asked to answer a number of questions based on the expert presentations, and to provide one section of a consensus document for discussion and amendment at a general meeting.

An additional group will work on an action plan, focusing on the organisation of a global 10-year campaign designed to raise awareness of the burden of musculoskeletal disorders, promote investment in prevention and research, create better treatment methods and improve the quality of life for patients. It is essential to acknowledge that no single professional group could accomplish such improvements.

The Bone and Joint Decade must be a joint multidisciplinary undertaking. I understand that this meeting is unique in welcoming representatives from all fields of musculoskeletal research and care, including patient's organisations.

It is a great honour and pleasure to open this meeting. I wish to extend a special welcome to the overseas representatives from Europe, Asia, North America, Australasia and the Middle East, to many international organisations and scientific journals, and to the World Health Organisation, one of the co-sponsors of the meeting. Welcome to Lund and to this important event.

Leni Björklund
Chairman of the Swedish Medical Research Council
Director of the Swedish Institute for Health Services Development

Summary

Musculoskeletal conditions are the most common causes of severe long-term pain and physical disability, affecting hundreds of millions of people across the world. The extent of the problem and its burden on patients and society can be understood from some examples:

1. *Joint diseases* account for half of all chronic conditions in persons aged 65 and over
2. *Back pain* is the second leading cause of sick leave
3. Fractures related to *osteoporosis* have almost doubled in number in the last decade; it is estimated that 40% of all women over 50 years in age will suffer from an osteoporotic fracture
4. The *severe injuries* caused by traffic accidents and war produce a tremendous demand for preventive and restorative help. It is anticipated that 25% of health expenditure of developing countries will be spent on trauma-related care by the year 2010.
5. Crippling *diseases and deformities* continue to deprive many *children* of their normal development.

The goals of the Decade are to improve the health-related quality of life for people with musculoskeletal disorders throughout the world by

1. raising awareness of the growing burden of musculoskeletal disorders on society,
2. empowering patients to participate in decisions on their care,
3. promoting cost-effective prevention and treatment,
4. advancing understanding of musculoskeletal disorders through research to improve prevention and treatment.

The campaign will promote initiatives in all parts of the world, with particular support for activities in developing countries. There will be collaboration with patient and professional organisations, research bodies and scientific journals. It will be launched at an international forum in 1999, with co-ordinated announcements made globally.

A series of consensus documents were prepared by selected non-expert groups, based on papers by experts in each of four chosen topics. The agreed and edited versions are appended. They were produced according to guidelines and may require further expansion and consideration. They provide useful outlines for the four clinical fields that had been selected, and an indication of the potential for advance in other musculoskeletal conditions. The common features in all four reports were the need for research and advance, the conviction that this would probably be cost-effective in the future, and an awareness of the very wide differences in standards and needs throughout the world.

At the end of the two-day meeting, the consensus document was agreed and an administrative structure set up for the next stages leading to the proposed launch. All the organisations joining the campaign will be represented on its Board, and a Steering Group will direct the project, which will not be linked to any other specific organisation. Donations will be requested from member organisations and other non-commercial organisations to fund the initial campaign.

Reports of the Consensus Groups

JOINT DISEASES

Joint diseases affect hundreds of millions of patients throughout the world, causing pain and disability with a great impact on families and on society. Osteoarthritis is the most common joint disease - in terms of years lived with disability it ranks second for women and fourth for men in the developed countries, and eighth in the whole world. Elderly patients are most often involved, and since the number of individuals over the age of 50 is expected to double between 1990 and 2020, the global burden of joint diseases will probably increase dramatically.

These conditions include a wide variety of systemic conditions and many regional and local articular and periarticular disorders. Better understanding of the causes and the development of new and effective therapies are likely to differ for these two general types of disorder. For the chronic forms it is important that fully informed and empowered patients are involved in the choice of management.

At present, treatment is largely focused on symptoms, but new studies of basic biology and pathophysiology will provide opportunities for improved diagnosis and novel forms of therapy.

Epidemiology

Recent work has answered some questions about the occurrence of diseases and affections of joints:

a) They affect people of all ages, and make major impacts on individuals, societies, and economic costs in all countries. The increases in the average age of populations will lead to more overall disability.
b) Prevalence varies throughout the world, but it is not known whether these differences have mainly genetic, lifestyle, or environmental causes. Exercise, lifestyle, education and overweight all influence the outcome, but the precise reasons are uncertain.
c) Osteoarthritis, the eighth most common cause of disability in the world, with great costs to society, has received disproportionately small investigative effort and funding.

Diagnosis

The early treatment of joint diseases, particularly of the inflammatory types, is known to improve outcome. This implies that early diagnosis is increasingly important to prevent or reduce long term disability.

a) Many diseases can now be diagnosed earlier, for example infective and inflammatory arthritis, but progress is hampered by insufficient knowledge of the early stages of the disease, especially osteoarthritis.
b) Better diagnostic criteria can now distinguish between over 200 forms of joint affections.
c) Newer imaging techniques such as MRI and ultrasound, and the use of arthroscopy can provide more precise early diagnosis of inflammation and articular damage.
d) Molecular markers now offer new insights into disease mechanisms and heterogeneity. Further developments will help to diagnose and monitor disease.
e) Current diagnostic approaches are not applied consistently, they vary considerably throughout the world.

Prevention

Joint diseases result from interactions between genes and the environment, which includes activities, lifestyles, diet, and various toxins. There is much evidence that incompletely known environmental factors are important both for the onset and the chronicity of joint diseases. Improved knowledge of these factors will help to create more efficient preventive programs. Current examples include:

a) Earlier diagnosis and treatment can prevent death in some life-threatening diseases such as systemic lupus erythematosus, and much reduce long-term disability in limb-threatening disorders such as infective arthritis.
b) The secondary infection of artificial joint replacements can be minimised by careful management. The use of condoms is associated with a reduction of arthritis associated with sexually-transmitted diseases. Hygienic food preparation minimises Yersinia-induced arthropathy.
c) Penicillin prophylaxis can prevent heart disease after rheumatic fever, but is not uniformly available or in regular use world-wide.
d) Some risk factors have been identified for certain forms of arthritis. These include excess weight and joint injuries, while some general lifestyles, diet, and impact activities are also believed to be associated with higher risks. It is uncertain whether these factors are causative or just contributory.
e) Early diagnosis of many forms of arthritis can re-

duce disability through treatment, education, and alterations in lifestyle and activities.

Therapy

In the last decade the treatment of some certain joint diseases has improved significantly.

a) Current treatments usually centre on the management of pain and disability, partly bacause of our limited understanding of the actual mechanisms of pain perception.

b) Patient education, and guided self-management, have improved outcomes, and better pharmacotherapeutic reduction of joint inflammation has reduced damage. New and more effective therapies are being developed to target specific inflammatory processes.

c) Mechanical forces play a critical role in regional and local joint disorders. The general relationships between the mechanical environment and tissue adaptation, destruction and repair are understood, but better detailed knowledge would make it possible to remove damaging mechanical conditions and optimise physical therapies. Some potentially good biological solutions may be ineffective at present because they s are overwhelmed by the mechanical environment.

d) Large joint replacement is very efficient for the most disabled patients, being one of the most cost-effective of all surgical procedures in any field. Long-term problems of loosening and wear, however, mean that it must still be used cautiously in younger patients, even when that are few reasonable and acceptable alternatives. Alternative treatments are required, such as osteotomy, or implants with greater longevity. At present there are very great variations in the use of joint replacement throughout the world, but inexpensive replacements for large joints are becoming available.

e) New and emerging patient-oriented measurements of outcome will provide far better assessment, of therapies as well as diseases. The assessments may need to differ between those treated with pharmaceuticals, physiotherapy, implants, and tissue-restoring approaches.

Future perspectives

The world's population is ageing substantially, particularly within the developing world. This and the increase in prevalence of many of the most common joint disorders means that the world-wide social and economic burden from these disorders will increase substantially in the near future. Some suggestions can be made to try to reduce this burden.

Epidemiology

We need to know the world-wide burden of joint disorders including their impact on individuals, societies, and economic factors. There is great need for data from developing countries, to allow the development of the most cost-effective strategies.

Better understanding of genetic and environmental interactions may come from study of the reasons for the regional variations in prevalence of various arthropathies.

Study of the changing incidence of joint diseases as societies undergo changes in living and working conditions and lifestyles will help to refine and develop standard outcome assessment tools for joint disorders focusing not only on disease parameters but also on functional outcome and quality of life.

Diagnosis

Most joint diseases can be diagnosed by history and physical examination, but these are not practised uniformly. New methods will allow more accurate diagnosis and therefore better choice and timing of therapy. Better education in current diagnostic approaches, especially the widely-available and more inexpensive methods, must be part of the training of health care professionals.

We should aim to identify the molecular events in disease processes to better delineate the pathophysiological processes. Gene mapping may ascertain the presence of risk factors in given individuals.

Prevention

The identification of environmental as well as genetic factors contributing to the emergence of severity of joint diseases will increase our potential for primary and secondary prevention. Emphasis should be placed on identifying factors influencing comorbidity and the psychosocial consequences of joint disorders.

Prevention of disability will be helped by the education of patients and health care providers, and more knowledge of situations which have strong associations with arthropathy, such as obesity, congenital and developmental disorders of childhood, and certain types of competitive and recreational activity.

Therapeutic developments

There is promise of major advances in the treatment of a number of joint diseases. Better understanding of the immune system will provide a basis for modulating the immune response in rheumatoid arthritis. Some emerging treatments have reached advanced trials and will be in clinical use in the next decade. The indications for their use require clarification and

obtaining necessary funds will need advance planning.

There is a window of opportunity to evaluate their effectiveness set against the very high current direct and indirect costs of treatment. Some examples are:

The development of molecules, taken orally, which are more effective at blocking tissue destruction and promoting tissue repair, and of less toxic and more effective anti-inflammatory drugs.

The optimal targeting of biologically active molecules to minimise inflammatory processes, reduce or reverse tissue destruction, and enhance tissue repair.

The establishment of gene therapy for conditions such as rheumatoid arthritis.

The identification of optimal combinations of existing therapeutic agents, and the development of tissue engineering for connective tissue repair and replacement.

Better methods of assessing the cost-effectiveness of new drugs and devices.

Recommendations

1. We need better understanding of the peripheral and central mechanisms underlying pain, using new technologies such as PET scanning. Research into the various physical and psychosocial factors that contribute to chronic pain will aid its treatment.
2. Prevent and cure the various forms of arthritis by defining mechanisms including genetic predisposition and major environmental triggers, as well as intra- and extracellular signalling mechanisms, including biomechanical factors.
3. Promote tissue-engineering techniques to repair or replace diseased or defective tissues.
4. Develop delivery approaches and techniques for bioactive molecules, including gene therapy.
5. Develop implant technology to enhance osseointegration and minimise wear, osteolysis and loosening.
6. Develop better reconstructive procedures for elbow, wrist, hand, ankle, and foot.
7. Identify strategies for the optimal patient selection and timing of joint replacement. Implement the use of centres of excellence for implant revision operations and the less common implants.
8. Assess new technology by multinational trials and registries using patient-oriented outcome tools.
9. Develop new aids and devices for disabled patients.
10. Develop cost-effective training programs for muscle strength and co-ordination in the elderly to enhance joint function and bone strength.
11. Support world-wide comparative epidemiological studies.

Specific goals

The main goal is the delivery of the appropriate treatment to individual patients, chosen from the many available. This needs exploring the optimum models for health care delivery, which may well vary in different cultural and economic environments. In chronic disorders, the informed and empowered patient must be a critical part of any therapy.

1. Both cutting-edge research and its clinical application are needed to develop cost-effective patient care.
2. Develop new therapeutic strategies to modulate and ultimately inhibit disease progression.
3. Decrease pain and improve function through more effective multidisciplinary use of education and current treatments. Emphasis on patient self-management will improve compliance and control of disease.
4. Better education of health care professionals, patients, the community, and policy-makers should use the current knowledge base with new methods of information transfer such as the Internet. Specialists in communication should help to maximise the transfer of knowledge and new research information; patient-advocate groups should be included in the communication network.

Final conclusion

Unless early investment is made in increased research and education to decrease the global burden of joint disease, the dynamics of these conditions in the aging population will generate an avalanche of costs, disability and suffering in the future.

OSTEOPOROSIS

Present state

In osteoporosis the reduced bone mass and changes in microarchitecture leads to an increased risk of fracture. These fractures are the serious, costly and important outcome of the condition, producing severe handicap and a considerable burden on society. The World Health Organisation definition of osteoporosis based on bone mass indicates many of the elderly population are at a high risk of fracture; at the age of 50 years women have a 15% and men a 6% lifetime risk of a hip fracture. The incidence of vertebral fractures among postmenopausal white women is about three times that of a hip fracture, but only about a third of them will present with clinical symptoms. Other fractures, such as those of the wrist, are also much more common in the elderly.

In the next 60 years demographic changes alone will produce a huge increase in such fractures as the world population ages. The number of hip fractures will rise from about 1.7 million in 1990 to 6.3 million by 2050 unless aggressive preventive programs are started. At present about half of the world's hip fractures occur in Europe and North America, currently suffer about one-half of all hip fractures, but there are already steep increases in Asia and Latin America.

Osteoporosis is a looming global problem that requires the identification of the population at risk; the use of currently identified preventive measures, and the development of new strategies for diagnosis, prevention and treatment. Patients at high risk can be identified best by measurement of bone mass, though ultrasound analysis may help. Other risk factors include stature, body weight and family history. New information and technology promise to improve diagnosis, prevention and treatment and exciting new research and therapeutic initiatives are likely in the next decade.

Future perspectives

The incidence of osteoporosis will continue to increase unless aggressive countermeasures are adopted. New methods of assessment and treatment are likely to be expensive, but the savings in cost of long-term care will offset such an investment. Improvement in nutrition and life style with increased physical activity has the potential to change the dramatically increasing prevalence of osteoporosis.

Diagnostic approaches

The measurement of bone density by DXA, SPA and QCT are good predictors of future fractures, but has limitations in accuracy and precision. They also fail to provide full insight to the underlying abnormalities in osteoporotic bone. Both bone mass and its architecture determine resistance to fracture. New technologies, such as micro-CT or MRI, are being developed to evaluate bone architecture in vivo. These will enhance the precision of risk assessment.

Other diagnostic techniques, including ultrasound, may have advantages over bone density measurements, by providing assessments of mechanical quality. Such methods may be more cost-effective. Another technique, using biochemical markers of bone turnover, may help determine the pathophysiological basis of osteoporosis and the effects of treatment. At present, biological variability limits the use of these measures to population screening; they are not yet applicable to evaluation of individual patients.

Prevention

Current methods vary considerably throughout the world, partly because of failure to implement recent knowledge. The most developed strategies include use of exercise, dietary modifications and drugs to maintain bone mass and prevent fractures. In the future there will be wider application of currently strategies and more use of new diagnostic tools and therapies.

It will be cost-effective to change the life style of children to optimise the skeleton during growth and adolescence by increasing calcium intake, improving overall nutrition and encouraging exercise. In developed countries, efforts must be made to decrease the incidence of anorexia nervosa, bulimia and excessive exercise; all these upset the hormonal environment and prevent attainment of maximum bone mass.

Other preventive strategies are needed at pivotal points in early adult life, such as early natural or surgical menopause, and the use of corticosteroid therapy. These periods require screening for osteoporosis and initiation of drug therapy when necessary.

Around the natural menopause, prevention should include screening for bone density, though cost may be a limiting factor. The screening of high-risk patients, chosen by family history, smoking, weight and body habitus may be a better choice, allowing appropriate education and treatment.

The occurrence of the first osteoporotic fracture should lead to screening, and the start of preventive measures and therapy. Patients over 60 years of age, particularly those with a history of repetitive falls, should have education and training to improve their balance and increase muscle mass. Institutions for the elderly should provide fortified diets, improved care and immediate environment, aimed at fall prevention. Hip protectors require more development and use.

Treatment

Current treatment of osteoporosis uses oestrogen or other anti-resorptive agents, such as bisphosphonates, calcitonin, calcium and vitamin D. All these may decrease bone loss and some have been shown to reduce fracture incidence. Calcium and vitamin D are also effective treatments for osteomalacia, which occasionally presents as osteoporosis. However, no therapeutic agent can substantially increase bone mass or improve the microarchitecture of the bone, and treated patients may continue to suffer some fractures.

Fluoride does increase bone mass and density, but does not reliably and uniformly reduce fracture incidence. Only calcitonin is reported to provide pain relief after acute fractures.

Many improvements in drug therapy can be foreseen on the basis of current research. The development of selective oestrogen receptor modulators (SERMs) has begun; new drugs are being designed to emulate the positive actions of oestrogen on bone without adverse effects on other organs, and may reduce the incidence of breast cancer. Further modifications of oestrogen may eliminate troublesome menstrual bleeding in elderly patients, improved compliance will benefit not only bone mass but also other positive aspects of oestrogen therapy.

New bisphosphonates may have less gastrointestinal side effects and more favourable therapeutic/toxicity ratios, but more time and continued research is needed into their long-term effects and complications.

Future drug developments will probably include anabolic agents, such as PTH, IGF-1 and growth hormone, which improve bone density and, through new bone formation, may eliminate some of the structural defects in osteoporotic bone. New combinations of anabolic and anti-resorptive agents may optimise desirable effects while decreasing side effects.

New strategies will be aimed at reducing the acute and chronic pain often associated with osteoporosis, and preventive measures against falls, with better support services for the elderly, will provide a better psychosocial environment.

Directions for research

Biomedical research has the potential to add important new information to our understanding of osteoporosis. Important aspects include:

1. *epidemiological* studies of prevalence throughout the world, particularly in the third world countries, will also give information on differences where fracture incidence is particularly low or high;
2. *health economy models* should be used to assess cost-effective treatment in relation to the cost of screening tests and treatment against that of chronic disability in future years;
3. *new diagnostic procedures* should provide insights into the structural defects in diseased bone and improve methods of assessing bone strength;
4. the design and implementation of new hormonal-metabolic agents to influence the bone remodelling cycle;
5. creation of *training schemes* and drugs for the elderly to augment muscle strength;
6. *genetic studies* have already shown that osteoporosis is inherited. Several candidate genes have been identified, but a complete picture will require both human population genetics and further animal studies.
7. *stem cell biology* may influence the declining number and activity of bone forming cells in normal ageing; replacement or regeneration of these cells may become possible, even in very old patients.
8. the *bone marrow environment* is poorly understood in relation to the immune system, but determination of the complex interactions may lead to new therapeutic options.
9. the *mechanical stimulation of bone* is an important field; bone is exquisitely responsive to loading. Under microgravity, or unloading due to inactivity or prolonged bedrest, bone is lost rapidly, and the study of the gravitational and mechanical stimulation of bone cells may provide new insights into stimulation of bone growth by the manipulation of natural signals.
10. more consideration is needed of the influence of osteoporosis on the outcome of orthopaedic reconstruction, particularly in relation to the preservation of bone mass around total joint replacements and its effect on fracture fixation.

Conclusions

The last decade has seen an explosion of fundamental and clinical research in osteoporosis. Large epidemiological studies have identified risk factors for low bone mass and fractures. Technological investigations have improved bone mass assessment and improved identification of those at high risk of fractures. Clinical studies have shown the efficacy of calcium and vitamin D supplements in a subset of elderly women and in maintaining bone mass. Physical activity has been associated with decreased bone loss and improved musculature and balance. Oestrogen replacement after the menopause reduces bone loss and fractures.

Despite this, effective therapeutic and preventive regimes for individuals at risk are little used. Advances in clinical medicine need implementation on a large scale to prevent the human and economic costs of an upcoming fracture epidemic. Behavioural and social science research is needed to use the important advances of the last decade.

Current basic research presents exciting opportunities and new avenues for "bench to bedside" translation. Progress will need interdisciplinary collaboration and the essential cross-fertilisation between scientific fields. Partnership between government, industry, voluntary organisations and patient advocacy groups can provide the fuel to drive the research and education agenda. The biggest beneficiaries will be the healthy and active ageing population of the world.

SPINAL DISORDERS AND LOW BACK PAIN

Over three-quarters of all people will have low back pain at some time in their life, and epidemiology indicates a prevalence in adults of 15% to 30%. Low back pain is the most frequent cause of limitation of activity in the young and middle aged, one of commonest reasons for medical consultation, and the most frequent occupational injury. In the industrial world about 2% to 5% of the population have a chronic back problem, and many are permanently disabled.

Present state

A few conditions such as disc herniation, spondylolisthesis and spinal stenosis are reasonably well defined and understood, but for a large number of patients with low back pain there is only fragmented knowledge and no effective hypothesis for the cause. The indirect costs of disability due to low back pain are enormous; they are much larger than the direct costs of medical diagnosis and treatment.

There are many problem areas:

- definitions and classifications;
- mechanisms of pain;
- relationship between imaging results and clinical findings;
- outcome measurements;
- the roles of non-operative and operative treatment;
- and the value of surgery, especially spinal fusion.

Most definitions of low back pain are based on the system developed by the Quebec Task force, but terms such as degenerative disc disorder and instability of the lumbar spine have a variety of interpretations. The pain receptors in spinal motion segments have been identified but there is little understanding of their clinical importance in the various back pain syndromes. The relationship between imaging observations and pain is not clear. There are some outcome measures but they are not satisfactory and fail to correlate with patient expectations.

Treatment is usually empirical, and although Back School therapy programs may benefit patients, they have not been shown to be effective in preventing recurrence. The role of spinal fusion in low back pain has been studied in very few randomised controlled trials and its long-term benefits need study. New surgical technology, including new materials, has not yet been shown to alter the outcome for low back pain.

Future perspectives

There is no reason to expect any spectacular changes in the frequency of low back pain, but public demand and expectation may increase and require more resources. The reported epidemiology of low back pain depends very much on individual perceptions, and socio-economic changes in developing countries may lead to an increased incidence of complaints of back symptoms.

The psychosocial and psychological factors in the chronicity of back pain need more study, using the instruments available. Clinical outcome studies that ignore these factors are so unreliable as to make valid conclusions impossible. Future epidemiological research will require much more precise definitions of back complaints and classifications of back problems.

The increasing age of the population will produce an increase in surgery for lumbar spinal stenosis. The risk of this type of surgery requires studies to determine the natural history of the condition, the risk/benefit ratios of surgery with and without spinal fusion, and the relative benefits of non-surgical treatments.

Back pain symptoms are subjective; better measurement tools are needed to quantify these assessments. The variability of complaints and the many different causes for back pain mean that such studies will need large numbers of patients in wide geographic and demographic ranges.

New diagnostic approaches

High risk patients with diagnoses such as tumour or infection need special tests and procedures.

Magnetic resonance (MR) imaging is a promising method, but more attention must be paid to interpretation of the findings and their relation to clinical symptoms. This also applies to other imaging techniques.

Some low back pain is related to segmental motion, and methods of studying this in vivo should be developed.

Increasing knowledge of the basic pathophysiology of low back pain and sciatica indicate that biological markers of nerve injury, inflammation and degeneration may be detectable in cerebrospinal fluid or serum. In the future pathophysiological processes may be detected by specific imaging techniques, such as targeting the molecular components related to disc or nerve injury.

Continued research is needed on the sensitivity and specificity of the various diagnostic tests including clinical, imaging and invasive methods such as discography. New diagnostic methods must also be assessed in this way.

More information about work and leisure requirements and patient's beliefs about back pain in relation to physical activity may provide important clues on management. One basic aim is better patient selection for different methods of treatment.

Prevention

Study is needed of interaction between clinicians and patients in relation to known practice guidelines, imaging and other diagnostic and pharmacological tests. Patient education should be directed to empowerment to allow better control of back trouble, for example by activity modification, general fitness and encouragement to return to normal function.

Such education should include body awareness, with enough ergonomic knowledge to be useful at work and in leisure activities. The relationship between age, levels of activity and load on the spine at work and leisure needs more study.

Expected developments

There will be advances in the understanding of the basic pathophysiology of low back pain and sciatica. Some experimental work indicates that both the epidural presence of tissue from the nucleus pulposus and mechanical deformations of the nerve root are necessary to induce sciatic pain due to disc herniation. Continued research may lead to new and improved treatment methods.

Specific anti-inflammatory drugs may be developed to target inflamed intervertebral discs, and gene therapy may become applicable to degenerative changes. Materials developed by tissue engineering could be delivered by endoscopy to replace disc material and restore disc space. All new possibilities must have careful evaluation by randomised clinical trials.

Surgery has a place in selected groups of patients. Spinal fusion may be by less invasive, percutaneous, using growth factors. New surgical procedures to replace elements of a motion segment may reduce pain and preserve movement by the use of flexible implants rather than rigid fixation. Biocompatible materials for spinal instrumentation will help to meet the new biomechanical and imaging requirements.

Early return to normal physical activity will probably be the treatment of choice for most patients with low back pain, using progressive, goal-related functional training and motor relearning on an interdisciplinary basis.

Future research

We need to know the natural history, causes and development of low back pain; at present we may be grouping very different conditions.

Increased knowledge of pain mechanisms will help to define the relevant structures, with focus on neurophysiological and neuropsychological responses in controlled experiments. Wind-up mechanisms, sensitisation in the central nervous system, and the role of inflammation in pain are important topics. Work is needed on nerve roots and dorsal root ganglia using markers for nerve injury and pain, chemical changes in the microenvironment, and neurophysiological changes in relation to imaging. The effect of controlled mechanical or biomechanical damage to spinal nerves on pain and automated, computerised behaviour analysis are of interest in experimental research.

The chronicity of pain needs study on the role of peripheral versus central mechanisms, using new technology such as PET scanning. Baseline data could be used for studies known and future pain modulating drugs and other methods of pain relief.

Biomechanical investigations of function can use new technology in vivo, which will help to clarify the motion-induced aspects of low back pain. Simultaneous neurophysiological recordings will link skeletal motion with soft tissue involvement.

Better education of patients and health care professionals will improve levels of care, and of knowledge about the function of the spine. This has great relevance because one section of the community undertakes increasing and possibly excessive sporting activity, while another larger section is becoming increasingly sedentary.

We need valid and reproducible outcome instruments for low back pain, spinal stenosis, work-related back injury, and sciatica including patient assessments and clinician-reported data. Randomised controlled trials (RCTs) are essential to investigate the effectiveness of various operative and non-operative management and preventive strategies. There is the need to apply the principles of Evidence Based Medicine. More precise indications are essential for the myriad of non-operative treatments such as manipulation, mobilising and stabilising exercises. The effectiveness of treatments such as acupuncture and TENs should be studied.

The place of primary care physicians in relation to hospital practice in the management of low back pain needs evaluation.

The local injection of selective drugs near a disc herniation may act at the interface between disc tissue and nerve root.

Pain influences movement patterns, speed and co-ordination, but it is uncertain how limitations and impairments are related to disability, and how pain relief influences functional restoration. Muscular co-ordination is changed by pain, and this will influence movement patterns. Physical activity may reduce pain and improve function, but the optimal dosage of activity during the time course of back pain is unknown. Another factor influencing disability due to back pain is the belief of the patient about physical activity in relation to tissue damage and healing.

Endoscopic surgery and procedures, using new imaging and computerised techniques, could reduce surgical trauma and shorten postoperative rehabilitation, but these approaches require proper clinical research and evaluation. A central register of new devices should be established.

New treatments should be assessed with care and subjected to economic research to determine their cost-effectiveness in terms of both the direct and indirect costs of low back pain.

SEVERE TRAUMA TO THE EXTREMITIES

Severe trauma is a major and increasing problem throughout the world, and it was difficult to restrict discussion to our specific title.

There were also problems in providing a general report on the whole topic. The first was the recognition that there is a wide spectrum of standards of care, not only across the world , but also within individual countries. Recommendations which are important to level 1 trauma centres in Europe and North America are less relevant in developing countries, but basic ideas and advances should be universally applicable.

Another problem was the lack of consensus for outcome assessment, which makes it difficult to differentiate between the results of different modes of treatment and also to assess the true value of extensive rehabilitation and retraining. The expectation of patients is also very variable—some consider that normality should be the outcome, however severe the original damage.

There is good evidence that severe trauma to the extremities is the leading cause of disability during the wage-earning period of life. Some 80% of tibial fractures occur in the 15–60 year age group, and after severe open fractures, only 28% are reported to return to their original work. The indirect costs of loss of earnings, benefit payments, compensation and support for such patients over very many years is not fully appreciated. It is clear from this that expenditure on trauma system organisation, treatment, and especially research is entirely justified, and would probably be cost-effective.

Positive factors in the care of patients with severe trauma include the progressive reduction in mortality at leading centres, the considerable increase in research into trauma and healing processes, and the widespread adoption of Advanced Trauma Life Support training. There is already an increased interest in outcome research. Some major centres have sophisticated systems for administration, patient transport, and general management, but these appear to be expensive.

Negative factors include the lack of firm indications for interventions, though it is recognised that these vary considerably with local circumstances. One instance of this is the lack of clear guidelines for amputation as against prolonged attempts at limb salvage. The same considerations apply to limb replantation. Guidelines will vary considerably with the circumstances in which patients are receiving care.

The hopes for improvement in outcomes as a result of subspecialisation within orthopaedics have not been completely fulfilled and in some instances such surgeons are unwilling to undertake general trauma care.

Epidemiology

Changes in the next decade are likely to include an overall increase in road traffic and industrial accidents. Any possible reductions in fully developed countries due to improvements in vehicle and road engineering and in industrial work practice will be more than balanced by increases in developing countries. The increased survival of severely injured patients, resulting from improved vehicle safety and better trauma care, will also produce an additional workload.

The acute and continuing care of increased numbers of patients will require additional manpower and a consequent expansion of training requirements. This need may be in conflict with the current trend to subspecialisation and raise questions about the place of trauma surgeons in general. This is recognised as a distinct speciality in some countries.

Diagnostic approaches

The most important diagnostic needs are improvement in the quality of physical examination, the understanding of the importance of tissue viability, and the quantifying of tissue injury. The latter may be better assessed in terms of functional units remaining, rather than as anatomical loss.

Better diagnostic facilities are needed for the assessment of peripheral nerve injuries. New tests or investigations which can distinguish between neurapraxia and axonotmesis would be valuable, as would tests which can distinguish between sensory and motor fascicles at nerve repair. The place of new techniques such as sophisticated imaging is uncertain in emergency circumstances, but each new method will require careful assessment and validation in view of the costs. There is great need for injury scoring systems which will correlate reliably with long-term outcome.

Preventive measures

Motor vehicle traffic is a major cause of severe limb injury. All the current preventive measures need emphasis and strengthening. At a personal level the use of helmets and restraint mechanisms is important. De-

creasing tolerance for the use of alcohol and drugs by drivers is essential. The skill and experience of drivers is a factor recognised in Canada by graduated licensing. For the first two years, new drivers are permitted no alcohol, and may not carry passengers in their own age group. The importance of speed limits and their enforcement, of improved road design and engineering, and of the separation of cycle lanes and pedestrian walkways are recognised. In some countries, pedestrian mortality now exceeds that of vehicle occupants. The general problem may be helped by coordinated transit policies which increase the use of much safer public transport.

Uncontrolled civilian access to fire-arms is responsible for increased severe trauma. The recent treaty banning the production, transport and use of anti-personnel land mines is welcomed, and the clearance of existing minefields is an urgent matter. Other less common causes of severe hand and limb injury are fireworks or other explosive devices.

Therapeutic developments

Fracture fixation

Operative fixation of open long-bone fractures is the standard for developed countries, but is not appropriate for some parts of the world. Readily available methods of fracture fixation should include reusable cheap external fixators, and implants with much lower cost and wider application. The need for removal of internal fixation was questionable, and needs review. The development of biological methods of fixation such as glues and bioactive implants require more investigation.

Fracture healing

There is need for more research into bone substitutes such as hydroxyapatite and allogeneic tissues. The place of bone stimulation, biochemical or physical, will become better defined in the next decade. Indications for the use of these new and different methods are now being developed, and clinical trials have started.

Wound care

The next ten years will see the primary closure of some open fractures with the aims of providing optimal conditions for bone healing and reducing infection rates. The development of a satisfactory artificial skin, tissue expansion, microvascular techniques and new methods of tissue transfer will also be important. We consider that the use of systemic antibiotics will be supplanted in some circumstances by newly available local delivery systems using bioabsorbable materials. New antibacterial strategies will be developed, which may include genetic modification techniques.

Methods of improving soft-tissue repair will become more important, with special attention to nerve regeneration. There may be future clinical application for the use of growth factors in nerve regeneration to stimulate axonal outgrowth.

Aftercare

The diagnosis and significance of thromboembolism in trauma patients needs better definition. New technology and methods will improve rehabilitation and retraining. It is important that the patient and family are involved at the earliest stages and are given realistic forecasts. There will be considerable improvements in artificial limbs, but it is essential to develop and fund the supply of simple, inexpensive designs for the developing countries. The more sophisticated prostheses will be used where they can be afforded, fabricated and fitted.

Specific goals

Arising from these current and anticipated developments, research is needed in many fields. These include:

1. acceleration of fracture healing, substitutes for bone;
2. soft-tissue regeneration, tendon healing, nerve regeneration and substitution;
3. control of scar remodelling;
4. ischaemia, revascularisation and reperfusion injury;
5. outcomes research;
6. trauma care delivery systems;
7. artificial limbs; and
8. the transfer of knowledge and appropriate technology to the developing world.

Improved *education and training* at the appropriate level has an early priority. The correct level will range from the basic requirements for medical and paramedical workers in the developing world, to the sophisticated and complex needs in major trauma centres. One suggestion was that the categorisation of such levels would be of value for travelling fellows in either direction.

The development of *systems for trauma care* must be related to national and local circumstances. Development can be regarded as an evolutionary process: the established systems in parts of Europe and North America represent the advancing edge of practice and research.

The basic goals for trauma care include efforts to decrease the number of injuries, to reduce mortality and morbidity, and to limit both direct and indirect costs.

Developed countries should refine their trauma systems to improve life and limb survival, using hierarchical referral where necessary by transfer agreements. They should continue advanced research.

Developing countries need a different emphasis. Basic care should focus on wound and soft-tissue management to minimise infection and mortality. Fracture care should normally be conservative, using plaster and simple traction, or minimally invasive, using wire and simple external fixators. As these countries evolve their improving medical infrastructure will be able to provide trauma care centres with triage and more specialised units. As such units develop, more sophisticated methods will become appropriate. *Subspecialisation* in orthopaedics and in other specialties creates some difficulty in providing comprehensive trauma care. Some areas require particular expertise, including the hand, the foot and ankle, peripheral nerves (especially brachial plexus) and the paediatric trauma patient.

The requirements for *education and training* vary widely, but surplus training positions on the developed world, at the appropriate level, should be offered to visiting fellows. The importance of the International Center for Orthopedic Education in the promotion of such schemes is recognised.

The general level of trauma care can be raised by initiatives such as Advanced Trauma Life Support training. The wider development and availability of trauma care delivery systems is constrained by geographical and resource considerations, but the correct strategies for the developed countries are indicated by available economic data.

The very large indirect costs of long-term chronic disability, some resulting from less than adequate primary care, need more emphasis. Resources should be diverted to minimise residual disability and accelerate return to work, which have important psychological, financial and social aspects.

It is clear that some of the massive amount of money involved in benefit payments, social support, and disability and compensation settlements could be better spent in more efficient treatment, with better and faster rehabilitation and retraining. It will be difficult to persuade governments and insurers that this is true.