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General Summary

Basic Research

Our studies of bone metabolism and osteogenesis have been highly acclaimed both in Japan and abroad. The research on bone metabolism has been focused on the relationship between osteoporosis and fracture risk. High levels of pentosidine in urine or blood and mild hyperhomocysteinemia, which suggest bone collagen abnormalities, might be used as surrogate markers for evaluating bone quality and for assessing the risk of bone fracture. Our studies of β-tricalcium phosphate (β-TCP) have played a pioneering role in the field of bone grafting. They have led to the wide application of β-TCP in many clinical settings; e.g., due to its efficient bone formation profile, β-TCP has been used as a complementary filling material in repairs of bone defects. Furthermore, studies of the relationship between micropores and osteogenic factors, such as bone morphogenic proteins (BMPs), have facilitated further understanding of the mechanism of osteogenesis.

Clinical Research

Our clinical practice has been divided into 9 subspecialties to treat a wide range of musculoskeletal disorders and is managed by different specialist teams: shoulder joint, hand surgery, spine, hip joint, knee joint, foot surgery, trauma, osteoporosis, and rheumatic diseases. All teams maintain a high level of expertise and are actively involved in scientific activities. The spine team has demonstrated the effectiveness of minimally invasive spine stabilization with the S2-alar-iliac screw for elderly patients with spinal deformities, especially sagittal imbalance in the lumbosacral region. The spine team has investigated surgical outcomes in patients treated with this technique. The knee joint team has been performing total knee arthroplasties with patient-matched instrumentation and has analyzed the effectiveness of cutting-edge technologies even more advanced than the surgical navigation system itself. Through this range of clinical research activities, all teams fulfill their important roles at a clinical academic hospital, and their commitment has been highly evaluated.

Research Activities

Outcomes of surgical treatment for proximal humerus fractures using multiaxial fixator plates

The outcomes of surgical treatment using multiaxial fixator plates for proximal humerus fractures in 9 patients were reviewed. The patients' mean age at surgery was 67 years,

and the average follow-up period was 2 years 9 months. Bone union had developed in all patients within 4 months. Avascular necrosis was not found in any patient after surgery. The mean ranges of motion at the final follow-up examination were 123-degrees elevation and 49-degrees external rotation. The mean Japanese Orthopaedic Association score was 86 points. The surgical treatment for proximal humerus fractures using multiaxial fixator plates produced satisfactory results. This system is indicated for markedly displaced 2- or 3-part fractures and even for 4-part fractures in young patients.

The current status of hand surgery

We treat many kinds of disease, from trauma, such as fractures, tendon ruptures and neurovascular injuries, to degenerative diseases and tumors. We also provide special surgical techniques for suturing tendons and for microsurgery. Over the last 10 years we have performed 300 to 400 operations of various types per year. After surgery, we cooperate with occupational therapists in the outpatient clinic to help patients achieve functional recovery. In clinical research, we analyzed collagen cross-linking in the hands of patients with Dupuytren contracture to clarify the etiology of this disease. We have started to administer antibodies against RANKL (receptor activator of nuclear factor kappa B ligand) to patients with recurrent or unresectable giant cell tumors of bone.

Surgical treatment for elderly patients with spinal deformities with a focus on sagittal imbalance at the lumbosacral region

Spinal imbalance negatively affects the quality of activities of daily life, especially in elderly people; therefore, surgery is occasionally performed to correct the spinopelvic alignment and to restore good sagittal balance. Although surgical treatments for elderly patients are invasive in terms of blood loss and operation time, we were able to reduce the effects of these factors by using a lateral access approach for lumbar spine fixation and to obtain good coronal or sagittal alignment. However, other factors that influence clinical outcomes include rigidity of the deformity and comorbidities, such as osteoporosis. Thus, strong fixation systems that provide efficient functional support of the lower lumbosacral vertebrae are extremely important. The S2-alar-iliac screw is one of strongest anchors at the lowest vertebral segments and is useful for spinopelvic re-alignments. We believe that the combination of the lateral access approach for lumbar spine fixation and instrumentation with the S2-alar-iliac screw system is extremely beneficial for treating elderly patients with spinal malalignment. Surgical outcomes of this procedure are being evaluated.

Treatment of infected total hip arthroplasty with a 3-stage articulating cement spacer method and preservation of the biologically fixed cementless stem

We have tried to preserve a tightly fixed stem in cases of cementless total hip arthroplasty (THA) and to create an articulating antibiotic-loaded cement spacer after removal of the acetabular cup with the twin aims of controlling infections and preserving hip function. Six cases of chronic deep infection after cementless THA were studied. Infections developed after 2 bipolar hip arthroplasties (BHAs), 2 primary THAs, and 2 revision THAs. The infections were successfully controlled in all 6 patients, and the second-

stage reconstructions were performed. Biological fixation of the cementless stem complicates implant removal while acting as barrier against bacterial invasion. An articulating acetabular cement spacer combined with a preserved cementless stem provided both infection control and preservation of hip function in all 6 patients.

Patient-matched instrumentation method in total knee arthroplasty: a prospective study of the accuracy of different patient-specific bone-cutting guides

Preoperative and intraoperative patient-specific templating has gained attention as the next technological development after computer-assisted surgery navigation systems in knee surgery. In our department, we have been evaluating the accuracy of implant positioning during total knee arthroplasty with patient-matched instruments and carrying out a comparative study against the computer-assisted navigation system. The evaluation also includes a comparative trial against conventional surgery, analysis of 3-dimensional reconstructions, and development of more-precise preoperative planning software. The comparative analysis of the accuracy of different patient-matched instruments is being carried out in a prospective manner.

Artificial reproduction of the weight-bearing state for the foot and ankle using a loading device designed for use with conventional computed tomography scanners

Computed tomography images obtained in the standing position are highly desirable for evaluating 3-dimensional bone alignment in foot disorders. We have designed a prototype loading device that can be used with a conventional computed tomography scanner and evaluated the reproducibility of the obtained data by comparing them with variables obtained in the standing position. The same axial pressure load corresponding to body weight was applied in 5 healthy volunteers lying in the supine position. With the subject's foot on the prototype device, the sole-ground contact area and the maximum-sole and center-pressure positions were measured and were compared with those obtained in the standing position. We could not find any significant differences between any of the respective values. Our prototype device allowed approximation of plantar load distribution and strength to those measured in the standing position.

Estimating bone material quality in the context of bone and vascular linkage

A reduction in sex hormone levels from middle age onwards, increasing age, and an overall increase in oxidative stress due to lifestyle-related diseases can reduce the quality of bone material in terms of collagen posttranslational modifications and cross-link formation. The intermolecular cross-link formation of collagen, which regulates bone-material properties, is a mechanism independent of bone remodeling. In other words, cross-link formation is controlled by the environment surrounding the bone matrix and is, therefore, influenced by cellular functions, oxidative stress, and glycation processes that occur in this environment. Because oxidative stress is also a risk factor for arteriosclerosis and cardiovascular events, low bone quality and arteriosclerosis should also be linked. High levels of pentosidine in urine or blood and mild hyperhomocysteinemia, which indicate abnormalities of bone collagen, might be used as surrogate markers for evaluating bone quality and for assessing the risk of bone fracture.

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