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Biological behavior and interaction of chondrocytes in fibringlue—an in-vitro culture study

H W J Koot, G N Homminga, P Buma, P M van der Kraan and W B van den Berg

Orthopedic Institute and Rheumatological Laboratory, University Hospital Nijmegen, the Netherlands

Objective: To investigate whether fibrin glue is a suitable transport medium for transplantation of chondrocytes.

Material and methods: Chips of cartilage from the knees of six-weeks-old New Zealand rabbits were dissolved in collagenase. The loose chondrocytes obtained were mixed with Tissucol® fibrin glue and cultured in RPMI medium with 10% FCS. The cell concentration ranged from $5x10^5$ to $2x10^6$ per ml. Every day a sample was examined with conventional optic microscopy, autoradiography and electron microscopy.

Results: On day one the cells were distributed homogeneously over the fibrin glue, without a pericellular matrix. From day two all solitary cells showed a fine round (chondrocyte) shape and were surrounded by a matrix that stained intensively with alcian blue. Labeling with 35S revealed silver granules round the cells as a sign of matrix production. Electron microscopically the cells contained dark secretion granules. From the third day cells in metaphase were seen as a sign of fission. This time, cell numbers and clusters formation increased, simultaneously with the dissolution of the fibrin glue. A direct relation with the cell concentration existed. After 7 days, 20–30% of the fibrin glue had dissolved.

Conclusion: Fibrin glue is a suitable biological transport medium for chondrocyte transplantation, but rapid dissolution of the glue at high cell concentrations may create difficulties for fixation of the transplant.

Development of a technique for use of femoral intramedullary bone grafts at revision surgery—a biomechanical and histological study in goats

BW Schreurs, R Huiskes, P Buma, J L M Slagter and T J J H Slooff

Department of Orthopedics, University Hospital Nijmegen, the Netherlands

As a solution for a major intramedullary femoral bone loss a technique was developed with which by impaction of a spongy bone allograft a cylindrical intramedullary graft in goat femurs was obtained. Subsequently, a cemented total hip prosthesis was implanted. The objectives were a) to obtain information concerning the stability of such prostheses and b) to make a histological study of the consolidation and incorporation of the graft.

To begin with, the stability immediately after implantation was studied in vitro in 4 femurs using roentgen stereophotogrammatic analysis. With the aid of a test bank, loads of 0, 200, 500, 800 N and 0 N, respectively, were imposed. The principal movements were axial rotation around the longitudinal axis of the prosthesis (max 2.1 degrees) and displacement in the distal direction (subsidence, max 0.500 mm).

In vivo, the above reconstruction procedure was carried out in 14 goats. The goats were killed after 6 (seven goats) or 12 weeks (seven goats). Of the seven goats per group, four were used for biomechanical and three for histological investigation.

During the biomechanical testing, one femur in the 6 week group was lost due to a technical problem. One specimen from the 12-week group showed loosening. In the other specimens the major movements were once again axial rotation and subsidence. The ranges of movement increased with heavier loads. The greatest rotation measured was 0.24 degrees with a load of 800 N. In nonweight-bearing condition some elastic recovery occurred. Ultimately, a maximal permanent axial rotation of 0.14 degrees resulted. The maximal subsidence at 800 N weight-bearing was 0.164 mm. In nonweight-bearing condition and after elastic recovery, a permanent displacement to a maximum of 0.078 mm remained. There were no significant differences between the 6- and 12-week groups either in rotation or in subsidence.

Histologically, revascularization, consolidation with the host bone and remodelling of the graft could clearly be observed. Bone destruction and apposition of new bone led to a mixture of graft and bone newgrowth. Bone remodelling was more pronounced in the 12-week group and at the proximal levels of the femurs. In two femurs of the 6-week group, signs of infection were observed. It is concluded that a cemented femoral prosthesis within a casing of impacted bone chips in goats is sufficiently stable biomechanically to allow incorporation of the graft.

Analysis and sensitivity of bacteriological cultures taken during explantation of bone allografts from postmortal donors

B R Veen[1], R M Bloem[2], P Petit3

[1]Foundation Bio Implant Services, Leiden Bone Bank, University Hospital, Leiden, [2]Department of Orthopedics, University Hospital, Leiden, and [3]Department of Microbiology, University Hospital, Leiden, the Netherlands

Introduction: The incidence of bacteriological contamination of bone allografts during explantation as reported in the literature ranges from 3 to 40%. Comparison of these series is impeded by the lack of clarity concerning the culture methods used. The results of the bacteriological cultures of 857 bone allografts in our bone bank were analysed retrospectively. In addition, the sensitivity of the culture method used was determined.Material and method: From 80 successive postmortal bone donors a total of 857 bone allografts were explanted. Donors with indications of presence of an infection were excluded. All explantations were performed under aseptic circumstances in an operating room. A culture was taken from every explant by rubbing a swab over the entire surface including the medullary cavity. Data on donor and explantation were recorded. Of 41 donors, a total of 75 fibular segments were cultured by the culture method described. These fibular segments were also cultured in toto.

Results: Contamination was observed in 471 of the 857 allografts (54.9%). Most of the contamination was caused by skin flora, in particular *coagulase-negative staphylococci* (n 425, 90.2%). The number of allografts contaminated with skin flora was significantly larger if more persons had been involved in the explantation ($p<0.0001$, chi-square test). Significantly more contamination with skin flora was also encountered if prior to the explantan, a multi-organ donation had taken place ($p=0.02$, chi-square test). On 37 allografts, highly virulent micro-organisms were cultured, especially Streptococcus spp. These highly virulent micro-organisms were cultured significantly more often from bone allografts from donors who had died from injuries ($p=0.006$, chi-square test). The sensitivity of the culture methods used could be established by comparing the results of the two culture methods applied. The sensitivity was established at 36%.

Conclusion: Bacteriological contamination of bone allografts during explantation occurs in a large number of cases. The principal source is skin flora of persons in the operating room. The donor may also function as a source. The latter phenomenon occurs in particular if micro-organisms are distributed through the body from a contaminated injury site. Donors with major injuries in these regions should not be accepted for bone donation. Owing to the low sensitivity of the culture method, in reality more allografts are contaminated with bacteria than established. These allografts have already been transplanted often, without leading to a higher incidence of infection than described in the literature. This suggests an acceptable bioburden.

Biocompatibility of wear-resistant ceramic coating

J J A M van Raay, P M Rozing[1], H K Koerten and C A van Blitterswijk[2]

[1]Department of Orthopedics, University Hospital, Leiden
[2]Biomaterials Research Group, State Universit,y Leiden, the Netherlands

There are indications that improving the surface finishing of the femoral component by means of a hard coating may substantially reduce the wear of the polyethylene of the cup.The general biocompatibility of four wear-resistant ceramic coatings was analysed in a cell culture of human fibroblasts. Titanium carbide (TiC), chromic oxide (Cr_2O_3), aluminum oxide (Al_2O_3) and titanium nitride (TiN) on cover glasses were introduced for 14 days into a cell culture. After 1, 4, 6, 10 and 14 days the cells were counted so that for each material a growth curve could be obtained that is a measure of the general biocompatibility. Data on cell morphology were obtained by optic and scanning electron microscopy.

Chromic oxide after as little as 2 days caused distinct changes of cell morphology followed by a massive cytotoxic effect on nearly all cells. The growth curves of cells cultured on titanium nitride, titanium carbide and aluminum oxide, on the other hand, were similar to that of the control culture. Also, there were no demonstrable morphological differences between cells cultured on these coatings and control fibroblasts. Accordingly, these coatings were regarded as biocompatible and they will be subjected further to tribological testing.

Formation in peripheral blood of antibodies against donor HLA antigens after ACL reconstruction with a bone-patellar tendon-bone allograft

P T H Langendijk[1], M RVeen[1], W J Willems[2], F Claas[3]

[1]Foundation Bio Implant Services, Leiden Bone Bank, University Hospital, Leiden, [2]Department of Orthopedics, Medical Center, Alkmaar, [3]Department of Immunohematology, University Hospital, Leiden, the Netherlands

Introduction: Reconstruction of the anterior cruciate ligament

by means of a bone-patellar tendon-bone allograft is one of the techniques nowadays advocated.[1,2,3] Using an allograft has many advantages. Potential drawbacks are transmission of infectious diseases and antigenicity. In the literature mention is made of immunological reactions after transplantation of deep-frozen or lyophilysed bone and tendon tissue. A prospective pilot study was carried out to determine whether after transplantation of bone-patellar tendon-bone allografts, formation of donor-specific antibodies in the peripheral blood can be demonstrated.

In 25 healthy young males and females with a chronic/isolated insufficiency of the anterior cruciate ligament, arthroscopic reconstruction was performed using a deep-frozen bone-patellar tendon-bone allograft. The grafts derived from post-mortal donors (15–55 years) and were processed prior to use. Donor and recipient were HLA-typed. Preoperatively and after one and three months the recipient's serum was screened for donor-specific antibodies. In case of a positive screening, a more sensitive determination (PRI) was carried out. All patients were screened for earlier pregnancies and blood transfusions.

Results: In three patients, seroconversion against donor-specific antibodies was found 3 months postoperatively. In two cases, the reaction was moderate to weak, in one case it was strong. Curiously, in one patient donor-specific antibodies were found preoperatively which postoperatively were no longer demonstrable.

Conclusion: Antibodies against foreign donor antigen may be formed after transplantation of a bone-patellar tendo-bone allograft. Seroconversion occurs only rarely, however. Possibly, the transplant loses antigenic potency due to the method of processing.

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Anterior-posterior laxity in mouse knees in an experimental osteoarthrosis model

G J V M van Osch, L Blankevoort, P M van der Kraan[1], B Janssen[2], E Hekman[2], W B van den Berg[1] and R Huiskes

Biomechanics Section, Orthopedic Institute, [1]Department of Rheumatology and [2]Instrument Development Service, University Hospital St Radboud, Nijmegen, the Netherlands

Osteoarthrotic lesions in a mouse knee may be induced by injecting collagenase. We have previously demonstrated that collagenase exerts no direct effects on the cartilage. In order to investigate whether collagenase leads to osteoarthrotic lesions through damage of knee ligaments, which causes instability of the joint, an Anterior-Posterior Laxity tester (AP-tester) was developed. Three days after injection of collagenase into the right knee of male mice, the back limbs were prepared free. Anatomical reference points on the bone were used to position the limbs firmly and reproducibly in the AP-tester, the knee in 60 flexion and the tibia in neutral rotation. Force and displacement between tibia and femur were measured between −1 and +1 N AP force. Collagenase-injected and contralateral knees of two closely related murine strains, C57BL6 and C57BL10 were compared. Histological sections were used to assess the osteoarthrosis. Collagenase significantly increased the AP laxity in both C57BL6 ($p<0.02$) and C57BL10 mice ($p<0.002$). C57BL10 mice were significantly more sensitive to damage of ligaments than C57BL6 mice ($p<0.005$). This is in agreement with findings in earlier experiments in which in the histological sections a higher incidence of osteoarthrotic lesions was visible in C57BL10 (80%) than in C57BL6 mice (25%). These findings confirm the hypothesis that collagenase-induced articular instability leads to osteoarthrosis and that more instability leads to a higher risk of osteoarthrosis.

A method to determine the structural mechanical properties of bundles in knee ligaments

T J A Mommersteeg, L Blankevoort, R Huiskes and J M G Kauer

Biomechanics Section, Department of Orthopedics, University of Nijmegen, the Netherlands

The ligaments of the human knee joint are composed of bundles with different mechanical properties. The forces in these bundles during knee movements depend on the mechanical properties and the activation of these bundles. For good understanding of the influence of the ligaments on the mechanics of the knee joint, knowledge of these two aspects is required. In this study a method was developed with which in an intact ligament the structural mechanical properties of the bundles can be determined. As an example, two anterior cruciate ligaments were subjected to tensile strength testing, with variation of the relative orientations of the insertions. Since during these various tensile strength tests different bundles are activated, the results each time show a different relationship between force and displacement.

These experiments were simulated by means of a computer simulation model consisting of four non-linear elastic line elements. Using this model, the forces in the line elements (ligament bundles) for each combination of orientation and displacement of the insertions can be calculated on the basis of a postulated relationship between force and displacement for each line element. The parameters that record this relationship are determined by minimizing of the differences between the calculated resultant of the line element forces in the model and the ligament forces measured in the experiment for each posture. This optimization results in a good model description of

the reality (the experiment). The resulting force-displacement relationships are different for the defined line elements or ligament bundles.The method described provides parameters that may be used to study the effects of a non-homogeneous distribution of mechanical properties in a ligament on the mechanics of the knee, and to predict the forces in the ligament bundles during knee movements without much experimentation.

The role of the non-collagenous osseous structural proteins in the pathogenesis of heterotopic ossifications

P Wuisman, A Bosse and K Schwarz

Department of Orthopedics, Westfälische Wilhelms Universität, Münster, Germany

The pathogenesis of heterotopic ossifications that develop in major cranial injuries is unknown. The basic cause is mesenchymal metaplasia. The stimulus(i) is (are) unknown. In order to gain more insight into this pathogenesis, we have carried out immunohistological investigations in 15 patients with a transverse section and heterotopic ossifications. With the aid of antibodies against non-collagenous osseous structural proteins and proteoglycans, the localizations of osteonectin (ON), bone sialoprotein II (BSP II), osteocalcin (OC), proteoglycan decorin (PG II), biglycan (PG I) and proteoglycan 100 (PG 100) were determined. The material comprised all stages of the heterotopic ossification (fibromyxoid to lamellar).

Results: For the various structural proteins, a differentiated distribution pattern, depending on the stage of ossification, could be established. In the early phase it was mostly the myxofibroblastic areas that stained, the expression shifted to the proliferating osteoblasts during the mineralization stage. In the late phase (lamellar bone) the expression dec reased. Only OC and PG 100 express in osteoclasts, the osteoblasts are no longer marked. PG II and PG I are mostly localized in the extracellular space. A heterogeneous distribution pattern was found in the cartilage.

Conclusion: The non-collagenous structural proteins and proteoglycans play a prominent part in the pathogenesis of the heterotopic ossifications and allow an immunohistological classificati on of the various ossification stages. In addition this investigation demonstrates that the fibroblasts are the osteoprogenitor cells and that the structural proteins PG 100 and OC play an important part in bone destruction.

Comparative biomechanical study of standard and experimental Souter-Strathclyde total elbow components implanted in cadaver material

R G Pöll

Department of Orthopedics, University Hospital Leiden, the Netherlands

Objective: The aim of this biomechanical study was to find the optimal proportion of the length of the intramedullary stem and the sizes of the medial and lateral epicondylar flanges of the humeral component, and the length of the intramedullary stem and the presence or absence of metal backing of the ulnar component of the Souter-Strathclyde cemented unconstrained total elbow prosthesis. These factors determine the degree of fixation and carrying capacity and the ease of insertion of the components of the prosthesis.

In an experimental study, in 24 frozen human cadaver elbows after thawing, 12 standard components were implanted on the right and 12 experimental components on the left. The humeral components were exposed to torsion forces in a Houndsfield test bank and the ulnar components to flexion forces.

Three experimental humeral components were inserted: 1) standard component with stem lengthened by 4 cm; 2) component with stem lengthened by 4 cm and reduced flanges; and 3) standard component without flanges, stem length 3 cm.

In addition three experimental ulnar components were inserted: 1) standard ulnar component with stem lengthened by 1 cm; 2) standard ulnar component with stem shortened by 1 cm; and 3) standard ulnar component, metal backed, stem length 2.5 cm.

Results: Mean failure load with standard humeral component on the right was 234 N, standard humeral component with lengthened stem +32%, standard humeral component with lengthened stem and reduced flanges +3%, and standard humeral component without flanges –36%. Failure load with standard ulnar component on the right was 914 N, ulnar component metal backed –27%, ulnar component with lengthened stem –14%, ulnar component with shortened stem –23%.

Conclusion: The most satisfactory ulnar component was the standard one. Regarding the humeral components, a choice can be made between a component with a lengthened intramedullary stem with reduced flanges and the standard humeral component.

Plasma and bone concentrations of cefuroxime and flucloxacillin after oral and parenteral administration

M M Alvarez Ferrero[1], T B Vree[2] and T J J H Slooff[1]

[1]Orthopedics Institut, [2]Department of Clinical Pharmacy, St Radboud Hospital, Nijmegen, the Netherlands

In spite of the widespread use of antibiotics in orthopedics, in the treatment of infections as well as for prophylaxis in arthro-

plasty and other operations, little is known about the mechanism of bone penetration. The literature contains no data on bone concentrations after oral administration.Twenty patients subjected to an arthroplasty of the hip or knee were divided into four groups and given cefuroxime and flucloxacillin prophylactically according to a predetermined protocol, orally as well as parenterally. Six blood samples and one corticospongious bone sample were taken perioperatively, in order to establish plasma level-time curves including a bone level.

Conclusions: After oral administration of cefuroxime and flucloxacillin no bone levels can be measured. In this respect there was no difference between one single dose and seven doses. After parenteral administration bone concentrations can be measured of both drugs. Cefuroxime reaches higher bone levels in spite of lower dosage (1500 mg vs. 2000 mg) (p=0.0277). The interindividual variation was high.

Patellar complications in total knee arthroplasty

D A Dartee, P J M G Eggen, J B A van Mourik and J A N Verhaar

Department of Orthopedics, University Hospital Maastricht, the Netherlands

Of 264 retrospectively studied primary total knee arthroplasties performed in the Maastricht University Hospital (227 women, 37 men), 9% (23 patients) were found to have patellar problems. In 218 cases the patella was replaced in the various types of knee prostheses used over the years. In the other patients the patella was left undisturbed or had already been removed at an earlier operation.

Of the 23 patients with patellar problems, 6 had not been subjected to patellar replacement: 3 were given a patellar prosthesis and 1 was subjected to patellectomy because of patellar pain and increasing patellofemoral arthrosis. To 2 Geomedic prostheses a Guepar type patellofemoral prosthesis was added.

Of the patients with patellar replacement, 8 showed lateralization of the patella during flexion (in 6 of these no primary lateral release). Complete luxation of the patella occurred in 5 patients. 4 of them ultimately were subjected to patellectomy.

In addition, a number of less frequent complications were observed. One patient had an avulsion fracture of the patella; patellectomy was carried out. Another patient had impaired wound healing over the patella with secondary signs of detachment which ultimately necessitated revision. Two patients had persistence of a painful patella without clear patellofemoral arthrosis, leading to patellectomy. The operations were performed by left-handed and right-handed surgeons. In this series, the left knee/right knee proportion was 1:1. A significant correlation was found to exist between patellar problems and operation of the knee on the opposite side of the surgeon's dominant hand (15:6).

Conclusion: It is found that the patella accounts for an important proportion of the postoperative complications; in this respect maltracking of the patella plays a substantial part. It is therefore of great importance that before wound closure the tracking of the patella is checked. In suitable cases, a lateral release may make a positive contribution to this. No relationship exists between a performed lateral release and the function of the knee.The position of the orthopedic surgeon during the operation may influence the postoperative patellar problems.

Prevention of patellofemoral problems in TCP knee prosthes

H M van der Vis, G H R Albers and C N van Dijk

Department of Orthopedics, University Medical Center, Amsterdam, the Netherlands

The principal disorders and complications in the Total Condylar Prosthesis are localized to the patellofemoral articulation. The main complications are: patellar fractures, loosening of the prosthesis, lateralization/subluxation, patellofemoral impingement (catching and locking) and patellofemoral pain. In our opinion, the following measures are to be considered to avoid these complications: minimal resection of the subchondral bone (to prevent fracture of the patella), lateral release (in case of peroperative tendency to lateralization), insertion of the prosthesis medially to the center of the patella (to prevent lateralization by reducing stretch on the lateral retinaculum) and insertion in slight exorotation of the femoral component of the knee prosthesis (method of Insall).

Patients and method: In the period 1984–1990 in all Total Condylar knee prostheses type Insall-Burstein II, the patellar prosthesis in principle was primarily placed medially by the same surgeon. In addition, the femoral component was cemented in 5–10 degrees of exorotation, which was achieved by resecting a larger part of the posteromedial side of the condylar block than of the posterolateral part. Finally, in all cases only minimal resection of the subchondral bone of the patella was carried out. A lateral release was not necessary in any of the cases. The objective of this study is to determine whether patellofemoral problems could be prevented.

Results: In the period 1984–1990, 36 Total Condylar knee prostheses type Insall-Burstein II were implanted by the same surgeon. Of these, 7 patients were found to have died and 3 to be lost to follow-up. In all, 26 could be followed up according to the protocol (Insall Knee Score, axial patellar radiograph and specific patellofemoral examination). None of the patients had a clinical patellofemoral impingement, there were no signs of loosening, no patellar fractures and clinically no lateralization. In 14 cases the axial patellar radiograph showed showed direct contact between the lateral prominent part of the patella and the femoral shield. In these cases there were reactive changes of the type of subchondral sclerosis and pressure atrophy. In five cases, this led to patellofemoral pain symptoms. 12 patients without this radiological abnormality had no symptoms.

Conclusion: Patellofemoral complications like loosening prothesis, fracture and patellofemoral impingement do no

occur in our group. We conclude that the preventive measures we have taken are effective. It is a drawback that the medial placement of the relatively small patellar prostheses may cause lateral friction, leading to pressure atrophy resulting in patellofemoral symptoms. This procedure is therefore not recommended.

Patellar problems in the GSB knee prosthesis

M A G de Kok and M C de Waal

Malefijt Department of Orthopedics, St Radboud Hospital, Nijmegen, the Netherlands

By means of a retrospective clinical and radiographic analysis of 90 GSB knee prostheses implanted in 75 patients between 1981 and 1987, the results regarding patellar symptoms and complications were assessed. Primary diagnoses had been rheumatoid arthritis in 42 and osteoarthrosis in 33 patients. Mean age was 61 (30–85) years, the male/female ratio 1:4. A type I GSB knee prosthesis was implanted in 21 knees (without patellofemoral arthroplasty) and a type II (with patellofemoral arthroplasty) in 53 knees. The Knee Society Clinical Rating System was applied.

For follow-up, 78 knees were available. Mean knee score was 82 for type I and type II. Mean function scores were 26 for type I and 42 for type II. The radiographic analysis of 71 knees revealed radiolucency >2 mm round the femoral or tibial component in only two cases. Pain symptoms involving the patella were present in 57% of the type I cases and 19% of the type II cases. Subluxations of the patella were seen in 5% of type I and in 26% of type II cases. Patellar fractures occurred in 5% of the type I and 10% of the type II cases. Arthrosis of the patellofemoral articulation was always associated with type I. A survival analysis showed a survival rate of 93% after 8 years.

Conclusion: The GSB has a low proportion of aseptic loosening, but does give rise to numerous patellar problems, particularly patellofemoral arthrosis in type I and (sub)luxations of the patella in type II.

Arthroscopic examination of the painful knee prosthesis

J B A van Mourik, J A N Verhaar, P J M G Eggen, D A Dartée, A van Kampen and M P Heyboer

University Hospitals Maastricht, Nijmegen and Rotterdam, the Netherlands

Arthroscopic inspection of a painful knee prosthesis is not a customary examination. Its role is a matter of considerable debate in the literature. No clear guidelines concerning the indication exist. The view has been advanced that certain ununderstood problems might be assessed with the aid of arthroscopy and that certain disorders might be treated arthroscopically. In this way, an arthrotomy might be avoided in certain cases. Objective of the retrospective study was to assess our results.

Patients: An arthroscopy was carried out in 25 patients with ununderstood persistent pain, hydrops or poor function after a knee prosthesis, 1 to 10 years postoperatively. The postoperative findings were interposing synovium twice, enhanced intra-articular adhesion formation four times, lateral or medial arthrosis in a uni-knee three times, erosion of polyethylene six times, loose prosthetic component three times, patellofemoral arthrosis four times and a torn meniscus once, while five times no cause of the symptoms was found. No postoperative complications occurred.

Conclusion: Arthroscopy may be a useful diagnostic method in case of obscurity regarding the cause of persistent symptoms after a knee prosthesis. An arthrotomy cannot always be avoided; the therapeutic possibilities of arthroscopy proved to be of limited use in this series. In view of the risk of damage to metal and polyethylene, arthroscopy of a knee with a prosthesis should be carried out by an experienced surgeon.

Ten years' experience of the Kinematic knee prosthesis

P J M G Eggen, D A Dartèe, J B A van Mourik and J A N Verhaar

Department of Orthopedics, University Hospital Maastricht, the Netherlands

A retrospective study was performed on 174 Kinematic total condylar knee prostheses performed between 1980 and 1988.

Patients and method: Indications for total knee repalcement were arthrosis in 147 patients and rheumatoid arthritis (RA) in 27. The mean follow-up was 3 years. A Kinematic PC type was used in 145, an AC type in 15 and a Stabilizer type in 14 knees. Patellar replacement was performed in 156 knees with lateral release in 70 cases.

Results: The mean preoperative range of motion was 110° and postoperatively this range was 100°. Postoperatively, minor complications occurred in 26 (15%) and deep infection in 7. In the follow-up period another 3 patients had deep infection of the knee. Treatment of infection resulted in 5 arthrodeses. 5 replacements survived after debridement, irrigation and gentamicin beads. Another 7 (4%) needed to be revised; 5 because of loosening. A femoral supracondylar fracture occurred in 2 knees. Patellar complications were seen in 16 (9%) knees.

Conclusion: The Kinematic knee showed generally comparable results to other unconstrained total knees. However, a significant number of major complications occurred such as infection, loosening and patellar maltracking, The complication rate in rheumatoid patients were twice as high as in arthrosis. The patellar problems might be related to the design of this prosthesis.

7 years' experience with the LCS (Low Contact Stress) total knee prosthesis

K J Hamelynck, H C Doets, P G M Olsthoorn, W P C A Winia and K Reynders

Slotervaart Hospital, Amsterdam, the Netherlands

A prospective study of the results of the LCS total knee prosthesis was started in 1984.

Patients and method: All the knees were scored preoperatively and once a year postoperatively according to the criteria of the Knee Society knee and function scores. Implantationwas performed in 80 men and 375 women. Mean age was 62 (19–90) years. Diagnosis was primary arthrosis deformans in 156 (34%), posttraumatic osteoarthrosis in 3, rheumatoid arthritis (RA) in 290 (64%), chondrocalcinosis in 3, hemophilia in one and osteonecrosis in two. The prosthesis was implanted in a primary situation (I) 323 times, and after a previous operation (II) 132 times.

Peroperative complications: Femoral fracture occurred once, fissure of femur or tibia 4 times, patellar ligament avulsion once and rupture of the popliteal tendon once.

Postoperative complications: Major wound healing disorder occurred 4 times, wound infection twice, intra-articular infection twice, peroneal damage five times of which once major. One disturbed wound healing (vasculitis in RA) and one intra-articular infection (loss of quadriceps function) necessitated removal of the prosthesis and arthrodesis of the knee. Wound healing disorders and intra-articular infections occurred exclusively in patients with RA.

Results: The mean Knee Society knee score amounted to 89 during the follow-up years 1 through 6. The mean score in primary knees was 90, in knees operated secondarily 87. The mean postoperative pain score was 47–48 in primary knees, 44–46 in secondary knees. Mean mobility was the same for all groups: 110 (40–140). The Knee Society function score improved substantially in all groups with in particular increase of the walking distance.

Problems during follow-up: In the first postoperative year one more major wound healing disorder and infection occurred, followed by arthrodesis. In the fourth postoperative year an intra-articular infection was treated with removal of the prosthesis, debridement of the infection and revision. Both disorders occurred in RA.

Aseptic loosening of components: Not a single femoral component, not a single patellar component, of the tibial components not a single rotating platform and not a single PCR (preservation of posterior cruciate ligament) tibial plateau loosened. Of the CR (preservation of anterior and posterior cruciate ligaments) tibial plateaus 7 loosened: twice in RA and osteoporosis, five times in arthrosis (four times after osteotomy of the proximal tibial and once after fracture of the tibial head).

Instability necessitated reoperation: Twice instability of the medial collateral ligament and twice instability of the posterior cruciate ligament. Instability of the posterior cruciate ligament led to meniscal dislocation in two patients and to patellar symptoms in two patients.

Summary: The LCS knee prosthesis system has yielded excellent clinical results. Postoperative problems such as wound healing disorder and infection are related to the diagnosis of RA. Aseptic loosening of components did not occur except of the CR component after earlier osteotomy of the proximal tibia.

Recommendation: After osteotomy of the tibial head, do not implant a CR component but a PCR component and in case of instability of the posterior cruciate ligament, do not implant a PCR component but an RP tibial component.

The Total Condylar Prosthesis in rheumatoid arthritis—analysis of 218 prostheses with a follow-up of 5–10 years

T de Jong, K J Hamelynck and P Bossuyt

Spaarne Hospital, Heemstede, the Netherlands

Objective: Assessment of the personal results of the Total Condylar prosthesis in rheumatoid arthritis patients and further analysis of the factors that influence the survival of the prosthesis.

Patients and methods: A retrospective study was made of 218 prostheses implanted in 153 patients, 130 women and 23 men with a mean age of 66 (35–87) years , in the period March 1980 through May 1985. The fate of all 218 prostheses could be determined. The clinical results were assessed using the HSS score. With regard to influence on prosthesis survival the following factors were taken into account: patient-bound factors: age, bone involvement, preoperative axis of leg, preoperative flexion-contracture, the pre- and postoperative Steinbröcker categories, the degree of bone destruction and previous kneeoperations ;surgeon-bound factors: the postoperative axis of the leg, correct placement of the tibial and femoral components, height of the tibial component, correct sizes of the components of the prostheses, postoperative stability, performance or non-performance of releases in case of preoperative abnormalities of the axis of the leg, flexion-contractures or faulty tracking of the patella. The prosthesis-bound factors considered were presence or absence of metal backing of the tibial plateau and the size of the prosthesis.

Results: Factors significantly influencing the survival of the prosthesis were a varus position of the tibial component of 5° or more, a valgus position of the femoral component of 10° or more, a femoral component too large in relation to the distal femur and absence of metal backing of the tibial plateau ($p<0.05$). In this group a total of nine infections occurred, one of them an early postoperative infection. Mean postoperative HSS score was 80. This remained virtually unchanged over the years.

The total condylar prosthesis in arthrosis

N Groot, P J A Schwering, T de Jong
and Dr K J Hamelynck

Ovre Lieve Vrouwe Gasthuss Amsterdam, the Netherlands

We report a retrospective study of the results of the Total Condylar Prosthesis in arthrosis.

Patients: From 1980 to 1985, 118 TC prostheses were implanted in 103 patients (98 women and 5 men). Mean age 77 (48–88) years. At follow-up examination the good clinical results of the TC knee prosthesis were confirmed: mean HSS score was 82 points.

Infection: Two infections were seen: once in the first year of implantation after a reoperation, necessary because of loosening resulting from a fall and once in the third year. The infection could be managed adequately by means of irrigation of the joint, irrigation system and intravenous antibiotics. No revision was performed. Infection plays a negligible part in OA patients, in contrast to RA patients.

Aseptic loosening: 13 cases: three times the tibial component, five times the femoral component and five times, both components. Causes of loosening was five times a surgical error: twice tibial component too small (component descended in varus), twice femoral component too large, once malalignment. Additional causes: injury once, instability twice, while four times the only distinguishing factor was an earlier osteotomy of the proximal tibia. At follow-up of the tibial components fixed without cement, a correlation was found between osteotomy of the proximal tibia and aseptic loosening of the tibial component. In 15 patients, osteotomy was performed prior to the implantation of a prosthesis: four tibial components loosened. Of the other 103 knees, nine developed loosening. In RA no correlation exists between aseptic loosening of the tibial component and (Benjamin) osteotomy. The factors found to contribute to aseptic loosening in RA proved to be much less involved in OA, and no significance could be established: a varus angle of the tibia of more than 5°, valgus angle of the femur of more than 10°, metal backing of the tibial component appears to be slightly preferable to no metal backing, thin tibial components better than thicker components. A valgus position of the femoral component exceeding 10° plays a part in the development of patellar complications. In this group there were two cases of patellar luxation, one loose patella and once, at implantation of a femoral component at an angle of 12° valgus, a partial patellar resection had to be carried out.

Conclusion: The total condylar knee prosthesis leads to acceptable but not excellent results. In assessing the results the preoperative diagnosis is important: infections occur virtually exclusively in RA, loosening of components is the consequence of surgical errors or of poor bone quality: osteoporosis in RA or status after osteotomy of the proximal tibia in OA, and placing the femoral component in 10° valgus or more on both diagnoses leads to patellar complications.

Insall knee score at follow-up of the Total Condylar knee prosthesis

G H R Albers, H M van der Vis, R v d Wijngaarden
and C N van Dijk

Department of Orthopedics, University Medical Center, Amsterdam, the Netherlands

The Knee Society in 1989 developed a new knee protocol. Its most remarkable difference from earlier protocols was the subdivision into a Knee Score and Function Score to eliminate negative influences on the patient's function not related to the knee prosthesis itself. The objective of this study was, apart from a follow-up of TC prostheses implanted by ourselves, to determine whether use of these different scores provides an objective picture of the function of the knee prosthesis itself.

Patients and method: In the period 1984–1991 in our hospital in 41 successive patients 45 Total Condylar Prostheses of the Insall-Burstein II type including patellar prostheses were implanted for primary gonarthrosis. The median incision was used. After-treatment consisted of 5 days' external splinting followed by active flexion exercises and mobilization with weight bearing. Of this group, 30 knees were followed up according to the Insall Knee Protocol. Data concerning another four patients were collected by telephone enquiry and from files. Seven patients had died so that four were lost to follow-up.

Results: As an early complication, regression of function occurred in four knees, necessitating passive flexion-extension exercises under anesthesia. In one knee, a hemarthrosis was evacuated arthroscopically and two showed transient wound-healing disorders. Mean duration of follow-up was 4 (1–9) years. Sex distribution M:F=1:5. The mean knee ROM at follow-up was101 (70–120) degrees. Radiographically no signs of loosening were observed. Mean Insall Knee Score was 77.5 (16–98) and the mean function score 56.1 (0–100). Subjectively, 70% were classified as excellent, 15% as good, 4% as fair and 11% as poor. Function score in our group was influenced negatively mainly by disorders not related to the knee prosthesis. This group included eight patients with complaints due to RA, loose hip prosthesis (3), low backpain, Parkinson's disease and pain in the contralateral knee (2). If this group was discounted, the Knee Score was 76.7 (16–98) and the Function Score 70.8 (20–100).

Conclusion: In view of these findings we consider the use of a Function Score to make little sense, since it is adversely influenced too much by irrelevant factors. Accordingly we propose at follow -up of knee prostheses only to use the Knee Score. Our results of the follow-up of TC prostheses are in agreement with the data in the literature.

The clinical score in total knee prosthesiology

R G H H Nelissen and P M Rozing

Department of Orthopedics, University Hospital Leiden, the Netherlands

In the period 1979–1986, 204 primary cemented total knee prostheses were implanted. The diagnosis was primary gonarthrosis in 55 knees and rheumatoid arthritis in 149 knees. Results were analysed using a survival score. For the clinical evaluation use was made of the Hospital for Special Surgery Knee Score (HSS). The results of the HSS score decreased as the follow-up period lengthened. The impression was gained that factors not related to the knee (patient function HSS) affected the score. To quantify this, at follow-up examination enquiries were made concerning the cause of a limited walking distance: the operated on knee, or factors not related to the operated knee (other articulations of the lower extremity, condition, back pain). Survival curve analysis showed an average survival of the knee prosthesis of 94% after 10 years (end point: revision or loosening of the prosthesis). The longer-term clinical results showed an enhanced influence of factors not related to the operated knee. Hip, ankle, condition and back symptoms in over 50% determined the patients' mobility (i.e. the HSS score) at the latest follow-up. Subdivision of a knee score (e.g. the HSS score) into a patient-related and a knee-related part will make possible more rational evaluation of the score.

A comparison of three models of knee prostheses in patients with rheumatoid arthritis

I E de Punder and M C de Waal Malefijt

Department of Orthopedics, St Radboud Hospital, Nijmegen, the Netherlands

In this retrospective study we evaluated the clinical and radiographic results of 217 total knee arthroplasties in 160 patients with rheumatoid arthritis. Successively, 113 Geomedic, 53 GSB and 51 Kinematic knee prostheses were implanted in patients with an average age of 60 years. At clinical review, the average follow-up periods were 11 years (Geomedic, range 7–15 years), 6 years (GSB, range 1–9 years) and 4 years (Kinematic, range 1–9 years). At follow-up a Knee Score and a Function Score were drawn up according to the Knee Society Clinical Rating System.

The average knee scores were 83 points (Geomedic), 39 points (GSB) and 55 points (Kinematic). Radiographic evaluation showed 35% malposition and 11% loosening of the tibial component in the Geomedic group. Fractures of the patella were noticed in 14% of the GSB knee prostheses with a patellar resurfacing. Revision of the knee arthroplasty occurred in 25 cases, 18 Geomedic, 5 GSB and 2 Kinematic prostheses. The prostheses were removed mainly for mechanical loosening in the Geomedic group and for deep infection in the GSB group. Survival analysis by actuarial methods was performed on all 217 knee arthroplasties. After 5 years, the cumulative survival rates were 88% (Geomedic), 90% (GBS) and 96% (Kinematic).

Conclusions: At clinical review there was no difference in the knee scores between the Geomedic, GSB and Kinematic knee prostheses. The difference in function scores probably was the result of the different average ages at clinical review. The cumulative survival rate of the Kinematic knee prosthesis was higher than the survival rates of the Geomedic and GBS prostheses after five years. This difference was not statistically significant.

The clinical and radiographic results of the uncemented PCA total knee prosthesis after a minimal follow -up of five years

M F van Trommel[1], M van der Linde[2], C P J Visser[1], A J Tonino[2] and A J M Sauter[1]

[1]Department of Orthopedics, Leyenburg Hospital, The Hague
[2]Department of Orthopedics, De Wever Hospital, Heerlen, the Netherlands

The objective of this retrospective study was to assess the medium-term results of the uncemented PCA knee prosthesis, using the HSS score and the radiographic knee evaluation and scoring system of the Knee Society.

Patients and methods: In the period 1983–1987, 100 PCA total knee arthroplasties were performed in 92 patients. At evaluation, 24 patients were found to have died, 10 could not be traced. Sixty-three knees of 58 patients were available for follow -up. Seven patients required a revision operation. These are evaluated separately.

The indications were osteoarthrosis in 75% and rheumatoid arthritis in 25% of the cases. Mean age at operation was 68 years. Mean duration of follow-up was 6 years. In all patients the HSS score was determined. Evaluation of the pre- and postoperative radiographs and the radiographs at the end of the follow-up was done using the RKESS.

Results: Of the patients 88% were satisfied with the operation. Mean Insall score was 75 (excellent 27%, good 39%, fair 27%, poor 7%). Mean function was 89. The femorotibial angle (FTA) was 174 (position 9.09) preoperatively and 176 (position 4.23) at the end of the follow-up. The position of the femoral part of the prosthesis on average remained unchanged. The posterior surface of the tibial plateau on average descended 4. In seven cases a radiolucent area of more than 1 mm was observed.

Conclusion: It appears from this retrospective series that the PCA total knee prosthesis in the medium term gives good results. In seven patients a revision was necessary, of the other patients 88% were satisfied.

Unicompartmental knee arthroplasty. A 1–5-year follow-up of the PCA unicompartmental endoprosthesis

M P Heyboer, A F Buitenhuis

Department of Orthopedics, University Hospital Rotterdam - Dijkzigt, the Netherlands

From April 1987 through July 1991, 63 unicompartmental knee arthroplasties were performed in 61 patients with gonarthrosis Ahlbäck stages I–III. The clinical findings were recorded using the Hospital for Special Surgery (HSS) score. Apart from the clinical score, standardized radiographic examination was performed preoperatively and periodically after the operation.

In 75% of the patients results according to the HSS score were good or excellent. Mean postoperative flexion amounted to 109±13 degrees. The position of the tibial component was 86±3 degrees in the anteroposterior and 88±2 degrees in the lateral direction; these did not change significantly during the follow-up. The same applied to the femoral component in the lateral radiograph .

In two patients revision was carried out because of loosening of the femoral and tibial components, respectively, while a third patient is on the waiting list for the same reason. Notwithstanding these favorable clinical short-term results, we discontinued use of this prosthesis after publication of the experiences with the PCA prosthesis in Sweden.

Migration and loosening of the polyethylene-fixing screw of the tibial component of the SKI knee arthroplasty

F Breukelman and J G Konings

Department of Orthopedics, University Hospital Groningen, the Netherlands

In the period 1982 to 1991, 345 total knee arthroplasties of the SKI type were performed in our department. In this prosthesis, the polyethylene of the tibial component is fixed to a metal backing by means of a screw.

Objective and method: Prompted by the fact that a number of patients were seen with loosening of this screw, this retrospective study was carried out to determine the incidence and nature of this complication.

Results: Loosening of the screw was seen in 14 (4%) patients, but only two patients had symptoms that could be ascribed to this. Loosening occurred after an average of 4 (1–9) years. In eight cases the screw remained in the screw hole, in six cases it was free in the joint. An arthrotomy was performed in eight patients, with removal of the screw in one case, in one other case a total revision was performed because of a coexistent aseptic loosening of the tibial and femoral components, and in six cases refixation of the screw was carried out.

Conclusion: Even in the absence of symptoms a dangerous situation may develop for the total knee arthroplasty due to loosening of a component of the prosthesis resulting from an imperfect design.

Revisions of knee prostheses: a continual technical adventure

P C G Hubach

Medisch Centrum, Alkmaar, the Netherlands

Knee prostheses being implanted more and more because of the good results, even in the long term, the number of revisions inevitably is increasing as well. In Alkmaar in the past 4 years 37 revisions were carried out in 30 patients. The revisions can be subdivided into five main groups: 1) surgical technical failure (5), 2) fractures (3), 3) simple loosening including the patella (11), 4) loosening with substantial bone loss (13), and 5) infections (5).

Revision arthroplasty of the knee imposes special conditions. *Technical:* a completely modular system, stabilized models (posterior-stabilized, semiconstrained), and intramedullary stabilization. *Osteoplasty:* autologous bone, and homologous bone (bone bank).

The technical problems concerning the prosthesis and the instrumentarium have largely been resolved. One major problem will continue to exist: the extensor mechanism. Adequate functioning of this mechanism, i.e. good tracking, is of cardinal importance for the ultimate functional result. At revisions this mostly required a capacity to improvise on the surgeon's part. In our series, adjustments were necessary in 22 cases.

Results: Group 1: one major complication, ultimately necessitating thigh amputation; groups 2 and 3: no complications; and group 4: in two cases retarded wound healing (in all cases (mean follow-up 1 year 9 months) good results); and group 5: so far, no recurrence of infections. One patient required two revisions and another patient even three.

Conclusion: It may be stated that revision operations of total knee prostheses should be carried out exclusively by surgeons with extensive experience of primary knee arthroplasties.

Bloodless mobilization of the knee after a knee arthroplasty

H W B Schreuder, M M Alvarez Ferrero and M C de Waal Malefijt

Department of Orthopedics, University Hospital Nijmegen, the Netherlands

In our clinic passive bending of knees is customary after arthroplasty if active flexion postoperatively is insufficient The authors are interested in the indication, the time of decision on this intervention, the functional results and the complications. Retrospectively, 29 patients were available for assessment.

Results:

Measuring time	Median days after arthroplasty	Median flexion
Before knee arthroplasty	0	89.6
After knee arthroplasty	1	92.2
Before passive bending	14	49.5
Immediately after passive bending	14	99.1
At discharge	22	85.7
First outpatient check	64	79.6
Second outpatient check	131	86.4
Complications passive bending:		
Anesthesia	none	
Fractures	none	
Loosening components femoral	1	(17 days after TKR)
tibial	none	
Wound dehiscence	none	
Hemarthrosis	none	
Insufficient improvement of flexion	5*	(14–22 days after)

*In these patients a second attempt or arthroscopic release was necessary, in three of the five with good results, in one case complicated by a wound infection and in one case without any functional improvement at all.

The mobilizations of the knees were performed on average 14 (9–62) days after the knee arthroplasty

Conclusions: The functional result of passive bending after a knee arthroplasty is approximately 40 degrees; this increased flexion is useful fora more normal gait and sitting position. Complications occur in 21%. Complications were not related to the moment of mobilization.

Alignment of the total knee prosthesis

N J A Tulp and R Huiskes

Department of Orthopedics, De Wezenlanden Hospital, Zwolle, the Netherlands

Correct alignment of a total knee prosthesis is of great importance. Possible complications of poor alignment include loosening of the prosthesis and erosion of polyethylene. The alignment in the frontal plane—with which this paper is concerned exclusively—in general is measured radiographicallly as the angle between the anatomical axis of the femur and the mechanical axis of the tibia (tibiofemoral angle). The question is, however, whether this is a good way of measuring the alignment. It is also possible, namely, to measure the position of the mechanical axis of the leg in relation to the center of the knee.

With most modern knee prostheses there is a choice between an intra- and an extramedullary alignment instrumentarium before placing the components. How can the effectiveness of the instruments be measured and what should preoperative planning comprise? Analysis of long/erect leg radiograph of 121 patients with total knee prostheses revealed a relationship between the tibiofemoral angle and the position of the mechanical axis of the leg. Consequently, both methods are suitable but neither supplies any information on the placement of the separate components. These can only be measured in long leg radiograph including head of femur and ankle.

For the femoral component: because the angle between the femoral prosthesis and the mechanical axis of the femur has to be measured to determine whether the placement is correct. When measuring as the placement the angle between the femoral prosthesis and the anatomical femoral axis, this angle should equal the angle between the anatomical and mechanical femoral axes. However, this angle can only be measured in radiographs of the entire femur. It is also this angle that has to be measured preoperatively if the intramedullary alignment instrumentarium is used.

Regarding the tibia it is found that the mechanical axis of the tibia does not always pass through the center of the shaft, so that here, also, radiographs of the entire tibia are required.

It is concluded that in case of use of intramedullary femoral instrumentatrium radiograph of the entire femur are required preoperatively and long erect leg radiograph postoperatively to measure the component placement and the alignment achieved.

A gait pattern analysis of the total condylar knee prosthesis

R G H H Nelissen, P M Rozin

Department of Orthopedics, University Hospital Leiden, the Netherlands

The postoperative results as a rule are assessed by subjective criteria. A gait study is a quantitative analysis of the postoperative result. After a knee replacement arthroplasty the maximal result to be obtained is a symmetrical gait pattern. This functional analysis of total knee prostheses (total condylar type with cruciate ligament resection) was carried out in a select group of the population of total knee prostheses. The study group consisted of patients who had undergone a unilateral knee replacement operation and in whom the other articulations of the lower extremity were not affected, so that the non-operated extremity could serve as a reference for the operated extremity.

The walking belt could be set at different angles to the horizon. The gait analysis data obtained were: walking speed, gait pattern data, flexion movements of the knee and EMG recording.

The study population comprised ten patients aged 46–81 years, with a mean follow-up of 4 years after operation. Symmetry rates for the gait phases between the operated knee and the normal knee ranged from 0.99 to 1.01 for horizontal, uphill and downhill walking. Flexion of the operated knee in the standing phase (horizontal walking) was reduced, EMG patterns were similar for the two knees.