Dynamic Evaluation of Contact Pressure and the Effects of Graft Harvest With Subsequent Lateral Release at Osteochondral Donor Sites in the Knee

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Purpose: To dynamically evaluate contact pressure about the periphery of the lateral femoral condyle in intact knees, to qualify the effects of osteochondral donor graft harvest on this contact pressure, and to quantify the effects of lateral release on contact pressure after graft harvest. **Type of Study:** Cadaveric analysis. **Methods:** Digital electronic pressure-sensing cells were used to measure contact pressure over the periphery of the lateral femoral condyle in 10 fresh-frozen knee specimens. Nonweightbearing resistive extension was simulated as the knees were placed through a functional range of motion. Dynamic pressure readings were evaluated over intact cartilage, around the rims of four 5-mm osteochondral defects, and after lateral release. **Results:** The pressure cells were all subjected to contact pressures as the knees were placed through a functional range of motion. Average maximal contact pressure progressed distally as the knees were flexed. The creation of 5-mm osteochondral defects did not lead to a significant increase in rim stress concentration over the surrounding cartilage. Lateral release resulted in small decreases in contact pressure over the osteochondral defects. **Conclusions:** The creation of 5-mm donor defects about the lateral aspect of the lateral femoral condyle does not lead to significant alterations in local contact pressure. **Clinical Relevance:** Our biomechanical findings may have important implications relating to cartilage restoration using osteochondral autografting procedures. Donor-site morbidity may be minimized if donor-site defects are limited to 5 mm and smaller. **Key Words:** Knee—Cartilage—Osteochondral autografting—Contact pressure.

Osteochondral autografting is commonly used to treat focal cartilage defects in weightbearing areas of the knee. Multiple donor sites have been recommended in the past, presuming that these areas are not only nonweightbearing, but nonarticulating as well. However, Simonian et al.[1] recently showed that commonly recommended donor sites about the periphery of the lateral femoral condyle and femoral notch are indeed subjected to contact pressure within a functional range of motion. Because pressure-sensitive film was used in this study, it has been suggested that contact may have been made between the quadriceps tendon and the trochlear articular surface at high flexion angles, rather than true articular contact.[2] Ahmad et al.[2] have suggested that this contact pressure may be caused by quadriceps tendon contact at high flexion angles, rather than true articular contact. Donor-site morbidity, although acknowledged by several authors, has not been thoroughly investigated. The implication of donor-site contact pressure is unknown.

Osteochondral defects in weightbearing areas of the knee joint are subject to rim stress concentration, and defects have been shown to cause secondary breakdown and degenerative change in surrounding carti-

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0749-8063/05/2106-3284$30.00/0
doi:10.1016/j.arthro.2005.03.001

lage. Brown et al.[3] reported that a defect in the weightbearing area of the canine femoral condyle causes rim stress concentration adjacent to the edge of the defect. This finding was later shown in the human cadaveric femoral condyle as well by Guettler et al.[4] Convery et al.[5] showed that an osteochondral defect greater than 9 mm created in the weightbearing portion of the medial femoral condyle in the Shetland pony leads to cartilage degeneration. Jackson et al.[6] showed that an osteochondral defect measuring 6 mm in the medial femoral condyle of the adult Spanish goat does not heal, but instead undergoes collapse of the surrounding bone and cartilage leading to a cavitary lesion. Messner and Maletius[7] reported on 28 young athletes diagnosed with isolated articular surface damage greater than 1 cm^2 in the weightbearing region of the knee joint diagnosed arthroscopically. At 14-years' follow-up, 12 of these patients had developed radiographic joint space narrowing of greater than 50% involving the damaged compartment.

Less is known, however, about osteochondral defects in nonweightbearing areas of the knee joint such as the periphery of the lateral femoral condyle. Lesions of 3 mm created in the trochlear groove in goat and dog models have generally healed, with bone and fibrocartilage filling the lesion.[8,9] Hangody et al.,[10] using second-look arthroscopy following mosaicplasty, found no cartilage degeneration adjacent to small harvest sites over the lateral femoral condyle, whereas Outerbridge et al.,[11] after harvesting larger osteochondral autografts from the lateral facet of the patella, noted radiographic patellofemoral degeneration in 5 of 10 patients.

We sought to build on previous studies through the dynamic evaluation of contact pressures over a donor site as the knee is placed through a functional range of motion. By creating osteochondral defects, rather than simply measuring pressures or determining loads over intact cartilage, we determine whether cartilage adjacent to these defects is subjected to increased or altered loading. We also evaluate lateral release as a logical method for decreasing contact pressures over these donor sites.

Our study focused on the periphery of the lateral femoral condyle above the sulcus terminalis where grafts are commonly harvested. Hangody et al.[10] preferred the quality of donor cartilage in this area, and Bartz et al.[12] recently showed that grafts taken from this area provide a superior topographic match for defects in weightbearing areas of the knee. The objectives of this study were to (1) dynamically quantify contact pressures about the periphery of the lateral femoral condyle as the knee is placed through a functional range of motion, (2) determine whether defects created in this area significantly alter contact pressures over adjacent cartilage and lead to rim stress concentration, and (3) determine the effect of lateral release on pressures over these donor sites.

METHODS

Ten fresh-frozen cadaveric knee specimens were used for this study. The specimens consisted of the entire leg amputated at the proximal one third of the femur. All specimens were examined and measured to ensure normal physiologic alignment. A lateral parapatellar arthrotomy was used to gain access to the periphery of the lateral femoral condyle above the sulcus terminalis. The patellofemoral joints were examined grossly to ensure that there was no significant arthrosis or maltracking. Four digital electronic pressure-sensing cells (Trimpad 9801; Tekscan, Boston, MA) were placed and mounted using small tacks. Care was taken to place the tacks away from the patellofemoral articular surface. This was possible because each sensor was surrounded by a nonfunctional area of laminate that could be used to gain secure fixation. On mounting, no gross motion between the sensors and the articular surface was detectable. Care was taken not to wrinkle or stretch the sensors. Each sensor measured 6.35×7.87 mm. The thickness of these sensors is 10 μm, and they are quite pliable. The sensors function using a piezoresistive pigment, and each sensor is capable of measuring the total compressive load within its surface area. The most proximal sensor was placed adjacent to the superior articular margin of the periphery of the lateral femoral condyle, and the most distal sensor was placed just superior and adjacent to the sulcus terminalis (Fig 1). On placement of the sensors, the lateral arthrotomy was closed with sutures, taking care not to imbricate the closure.

The knees were loaded through the quadriceps tendon simulating nonweightbearing resistive extension against a constant load of 100 N, as described in previous studies.[1,13,14] The force was applied in line with the anatomic axis of the femur. This loading axis was similar to those used in previous studies.[1,15-17] The knees were then placed through a functional range of motion from 0° to 110° at a constant rate of 10° per second. This was done manually. A Schaevitz clinometer (Schaevitz Sensors, Hampton, VA) was used to measure the angle of the leg with respect to gravity. The sensor was fixed to each tibia using screws. Real-

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