The use of biodegradable fixation devices in the treatment of osteochondritis dissecans and osteochondral fractures
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CHAPTER 2

The use of Biodegradables in the Treatment of Osteochondritis Dissecans of the Knee: Fiction or Future?

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The use of biodegradable fixation devices in the operative treatment of osteochondritis dissecans of the knee could avoid a second operation for removal of the hardware, but what are the disadvantages? Seven osteochondritis dissecans lesions, non-displaced in four adult knees and in one adolescent knee and displaced in two knees of adolescents, were treated by drilling and stabilization with biodegradable pins, resulting in primary consolidation in the five non-displaced lesions and failure in the two detached lesions. However, two detached fragments in adults, primarily fixed with one metallic compression screw and three biodegradable pins both consolidated. In another adult patient, the fixation with two compression screws failed. A study of the available literature and the results of our limited experience seem to indicate that the primary operative treatment of choice of a non-detached osteochondritis dissecans lesion is drilling and fixation with biodegradable pins. However, if this regimen fails or in patients with a detached lesion, one metallic screw and a few additional biodegradable pins appear to constitute the best method of fixation. The use of biodegradable screws is still hazardous, because of the long degradation time and subsequent risk of erosion of the opposite cartilage and tissue reaction. Other resurfacing options are available for failures or fragmented or non-vital lesions.

INTRODUCTION

Fixation of the detached fragment, if it is vital and intact, is the best option in the treatment of osteochondritis dissecans (OCD) of the knee, especially in adults. Removal of the fragment increases the risk of early osteoarthritis. Metallic fixation devices such as pins or K-wires, hooks, staples and screws are being used, all, however, with implant-related disadvantages. Most of them have to be removed during a second operation. If they are left in place, they may erode the opposite cartilage of the tibial plateau or they may break and they may also disturb subsequent diagnostic procedures such as computed tomography or magnetic resonance imaging. Some metals like chromium, nickel, gold, platinum and cobalt may evoke allergic reactions varying from eczema to anaphylactic shock. Finally, chromium, nickel and cobalt are also potent carcinogens in animals. These disadvantages stimulated the application of biodegradable devices, such as pins, bone pegs, bone cylinders, tags, pins, and glue have poor mechanical properties and have a poor ability to provide sufficient compression between the fragments and stability. Screws, on the other hand, may erode the opposite cartilage surface due to their long degradation time and their dimensions.

The aim of this paper is to present the results of the use of biodegradable (bd.) pins in a series of patients and to evaluate the presently available biodegradable devices for fragment fixation in the treatment of OCD of the knee.
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PATIENTS AND METHODS

From 1989 till 1998, 10 knees in nine patients (six adults, two females and seven males) were operated on for a symptomatic OCD lesion (Table I). The average age at operation was 24 years, with a range from 14 to 33 years. The right knee was involved in six patients, the left knee in four patients. All lesions except one were located on the medial femoral condyle. The lesion was still attached in five cases (Figure 1), it was partially detached and connected to the condyle by a bridge of cartilage in four cases (Figure 2). In one patient (# 3) the fragment was completely detached. The size of the fragments ranged from 0.8 to 3.6cm². All patients complained of pain, effusion and sometimes of locking, cracking or the sensation of a loose body. The onset of the symptoms varied from three weeks to eight years before the operation, starting intermittently and getting worse and more frequent over time. One patient (# 3) had an acute event, twisting his knee, after three weeks of vague pain (Table 1). Two different treatment strategies were applied, depending on the status

Table 1.

<table>
<thead>
<tr>
<th>Nr</th>
<th>Sex</th>
<th>Age at op.</th>
<th>Med/Lat</th>
<th>Side</th>
<th>State</th>
<th>Size (mm)</th>
<th>Complaints</th>
<th>Since</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>f</td>
<td>15 yr</td>
<td>lat.</td>
<td>left</td>
<td>detached</td>
<td>15 x 12</td>
<td>pain, effusion, locking</td>
<td>4 years</td>
</tr>
<tr>
<td>1.2</td>
<td></td>
<td>19 yr</td>
<td>med.</td>
<td>right</td>
<td>attached</td>
<td>15 x 15</td>
<td>pain</td>
<td>6 weeks</td>
</tr>
<tr>
<td>2</td>
<td>m</td>
<td>16 yr</td>
<td>med.</td>
<td>right</td>
<td>attached</td>
<td>15 x 15</td>
<td>pain, effusion</td>
<td>3 years</td>
</tr>
<tr>
<td>3</td>
<td>m</td>
<td>14 yr</td>
<td>med.</td>
<td>right</td>
<td>detached</td>
<td>20 x 15</td>
<td>pain, effusion</td>
<td>3 weeks</td>
</tr>
<tr>
<td>4</td>
<td>m</td>
<td>28 yr</td>
<td>med.</td>
<td>left</td>
<td>attached</td>
<td>18 x 15</td>
<td>(night) pain, locking</td>
<td>6 years</td>
</tr>
<tr>
<td>5</td>
<td>m</td>
<td>26 yr</td>
<td>med.</td>
<td>right</td>
<td>detached</td>
<td>20 x 15</td>
<td>pain, effusion, locking</td>
<td>8 years</td>
</tr>
<tr>
<td>6</td>
<td>m</td>
<td>25 yr</td>
<td>med.</td>
<td>right</td>
<td>attached</td>
<td>20 x 15</td>
<td>effusion, cracking</td>
<td>3 weeks</td>
</tr>
<tr>
<td>7</td>
<td>f</td>
<td>24 yr</td>
<td>med.</td>
<td>right</td>
<td>detached</td>
<td>20 x 12</td>
<td>pain, effusion, locking</td>
<td>1 year</td>
</tr>
<tr>
<td>8</td>
<td>m</td>
<td>23 yr</td>
<td>med.</td>
<td>left</td>
<td>attached</td>
<td>20 x 12</td>
<td>(rotatory) pain, effusion</td>
<td>3 weeks</td>
</tr>
<tr>
<td>9</td>
<td>m</td>
<td>33 yr</td>
<td>med.</td>
<td>left</td>
<td>detached</td>
<td>20 x 15</td>
<td>pain, effusion, locking</td>
<td>10 years</td>
</tr>
</tbody>
</table>

Figure 1. Bulging cartilage of a non-detached OCD lesion in the medial compartment of a right knee. A test probe is seen at the bottom.
of the fragment. The first strategy was arthroscopic drilling for revascularization and fixation with biodegradable pins (Figure 3), with a diameter of 1.5mm (Orthosorb®, Depuy, Johnson & Johnson, Warsaw, Ind., U.S.A.). The indication for the first regimen, applied seven times, was adolescent age or incomplete detachment of the fragment. In one patient from the first group, a two screw-fixation and minced autologous cancellous bone transplantation was used secondarily, after fixation with pins had failed (patient # 3). The second strategy, used in three cases, was abrasion, minced autologous cancellous bone transplantation and metallic compression screw fixation. The indication was skeletal maturity or detachment of the fragment. In two patients (#5 and # 9) in this second group, one centrally placed metallic screw, providing compression, was combined with biodegradable pins, providing rotational stability (Figure 4). First, arthroscopic debridement was performed using a saline solution as irrigation fluid. Subsequently the joint was temporarily filled with CO₂ gas during
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**Figure 4.** One screw and 2 biodegradable (blue) pins, 6 weeks after implantation. A thin layer of newly grown cartilage is covering a substantial part of the head of the screw. (see for color image: page 137)

In one patient in this second group (patient # 7), two screws were used primarily for fixation of the fragment, owing to its large size (Figure 5). Postoperatively all knees were immobilized for two weeks in a plaster splint, followed by a hinged brace for three weeks. Continuous passive motion was applied during this period. Patients from group 1 started weight bearing about six weeks postoperatively, after radiological confirmation of the healing process. Patients treated with screws started progressive loading immediately after screw removal, 8 to 12 weeks after insertion. The follow-up time was between five and 12 years with an average of nine years (Table 2).

<table>
<thead>
<tr>
<th>Nr</th>
<th>Sex</th>
<th>Age</th>
<th>Implant</th>
<th>Complications</th>
<th>Secondary treatment</th>
<th>Result</th>
<th>FU</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>f</td>
<td>15</td>
<td>4 pins (A)</td>
<td>no consolidation</td>
<td>perichondrium transplantation (O)</td>
<td>healing</td>
<td>12 yr</td>
</tr>
<tr>
<td></td>
<td></td>
<td>19</td>
<td>4 pins (A)</td>
<td>no</td>
<td></td>
<td>healing</td>
<td>8 yr</td>
</tr>
<tr>
<td>2</td>
<td>m</td>
<td>16</td>
<td>5 pins (A)</td>
<td>consolidation, effusion, pain</td>
<td>2 x drilling, shaving (A)</td>
<td>healing</td>
<td>11 yr</td>
</tr>
<tr>
<td>3</td>
<td>m</td>
<td>14</td>
<td>4 pins (A)</td>
<td>non union in 6 weeks</td>
<td>cancellous bone transplantation 2 compression screws (O)</td>
<td>healing</td>
<td>11 yr</td>
</tr>
<tr>
<td>4</td>
<td>m</td>
<td>28</td>
<td>6 pins (A)</td>
<td>no</td>
<td>shaving at screw removal (A) repeat shaving (A)</td>
<td>healing</td>
<td>10 yr</td>
</tr>
<tr>
<td>5</td>
<td>m</td>
<td>26</td>
<td>1 screw 3 pins (A)</td>
<td>cartilage fraying adhesion</td>
<td></td>
<td>healing</td>
<td>8 yr</td>
</tr>
<tr>
<td>6</td>
<td>m</td>
<td>25</td>
<td>5 pins (A)</td>
<td>no</td>
<td></td>
<td>healing</td>
<td>8 yr</td>
</tr>
<tr>
<td>7</td>
<td>f</td>
<td>24</td>
<td>2 screws (A)</td>
<td>no consolidation</td>
<td>perichondrium transplantation (O)</td>
<td>healing</td>
<td>7 yr</td>
</tr>
<tr>
<td>8</td>
<td>m</td>
<td>23</td>
<td>5 pins (A)</td>
<td>no</td>
<td></td>
<td>healing</td>
<td>6 yr</td>
</tr>
<tr>
<td>9</td>
<td>m</td>
<td>33</td>
<td>1 screw 3 pins (A)</td>
<td>no</td>
<td></td>
<td>healing</td>
<td>5 yr</td>
</tr>
</tbody>
</table>

A: arthroscopic procedure
O: open procedure

Table 2. Treatment and result
Primary healing occurred in all five knees with non-displaced fragments, drilled and fixed with pins only (Table II). In one of the knees with a partially detached lesion, re-fracture or insufficient healing led to dislocation of the fragment during a squatting movement (patient # 1, first knee), three months after the first operation. After fragment removal and drilling of the bottom of the defect during a second procedure, pain and joint effusion persisted for six months. In a third procedure, perichondrium transplantation was performed and the symptoms disappeared. In the adolescent patient # 3, the totally dislocated fragment was replaced and fixed with four biodegradable pins. No healing was seen on the radiographs after eight weeks. During control arthroscopy the fragment was found to be mobile. To create optimal conditions for healing, the fragment was lifted, the fibrous bed was abraded and cancellous bone transplantation was performed, which was followed by fixation of the fragment with two compression screws. Healing occurred in six weeks. In a third patient (# 2) in the pin fixation group, the knee showed a persisting slight effusion and vague pain, although the fragment healed radiologically. After two additional arthroscopic debridements with drilling of the irregular margins of the fragment, the complaints vanished. Primary healing occurred in both patients (# 5 and #9) in which one screw and three biodegradable pins were used. In one patient (# 7), initial fixation with two screws failed. Subsequently the fragment was removed and the crater was drilled. Pain and a slight effusion persisted. After perichondrium transplantation she became free of complaints as well.
DISCUSSION

As early as 1558, more than 500 years ago, Paré described the removal of loose bodies from a knee joint, probably the first paper about the treatment of an OCD patient.27 However, more than four centuries later the origin of OCD of the knee is still unexplained and the treatment still not uniform. The behavior of OCD closely resembles pseudarthrosis,6,47 but no consensus exists about the treatment of choice.

In adolescents spontaneous healing was believed for a long time to be the natural course of OCD21,25,33,43 and treatment was conservative. However, failures of this regime became evident13,17,24,33 and although spontaneous healing did sometimes occur, the outcome was unpredictable. More recently operative treatment, such as drilling, has been advocated in the literature.13,17,24,47 In the adult, simple removal of the fragment proved to be as unpredictable as in the growing individuals, with even worse results. Repositioning of the original fragment, if intact, is more and more considered to be the treatment of choice.4,6,19,27,47 To optimize the conditions for healing, curettage or abrasion of the bed, cancellous bone transplantation and fixation with compression is advocated.4,19,26,27,34,38 Most of the metallic fixation devices have to be removed during a second operation.14,17,27,34,38,46,47 Staples, if left in place, tend to break (9 out of 28 patients) and consolidation only occurred in 15 out of 28 of the patients in one series.29 Obviously staples do not provide a stable, compressive fixation like a screw. Herbert screws and Smillie pins could be left in place as well, but can still cause erosion by shedding on the long run.14,47 Furthermore, they can disturb subsequent MRI and CT imaging and, finally, they carry the risk of allergic reactions and have a carcinogenic potential.12 The use of biodegradable devices could possibly solve these problems. However, screws, with their large cross-section compared with pins, produce considerable holes in the often tiny fragments and may cause erosion of the opposing cartilage.23,32 In contrast, the more delicate biodegradable pins cannot achieve absolute stability and compression. In the adolescent, with a more favorable prognosis due to a higher natural tendency to healing, only drilling is advocated in the literature, if the fragment is not fully dislocated. Stabilization with small biodegradable pins can provide additional stability in this situation, as was successfully done in patient #2 with a bulging, not detached lesion. If the fragment is partially or totally detached, some fixation is mandatory. In our series, simple pinning failed in the patient with the totally dislocated fragment (#3) and in the patient (# 1, 1) with subtotal detachment of the fragment. This situation in adolescents seems to be an indication for primary compressive fixation as well, as was done in the second operation in patient #3 and in the adult patients.

In the adult with the detached lesion, the current treatment of choice of OCD of the knee is stable fixation with compression after debridement of the bed and cancellous bone transplantation. One metal compression screw fixes the fragment under compression. Surrounding the screw by a few biodegradable pins instead of inserting another screw improves rotational stability. With one 2.7mm screw and three Orthosorb® pins with a diameter of 1.5mm, the damage caused to the often
tiny fragment is more diffuse and less than with two more bulky screws. The arthroscopic insertion of a metallic screw and its removal, after healing of the fragment, is likely to be less harmful than the use of a biodegradable screw, because the latter may cause erosion of the opposite cartilage surface due to the long degradation time, as it is not imbedded.\textsuperscript{24,25} Whereas polymerized poly (L-lactide) takes more than six years to be absorbed\textsuperscript{9}, semi crystalline poly (96L/4D) lactide (PLA96) and the, initially, amorphous poly (50L/50D)lactide (PLA50/50) take considerably shorter, ranging from more than 101 weeks (80 mg PLA96) to 32 weeks (80 mg material, PLA50/50).\textsuperscript{10} Small polyglycolic acid rods were found to dissolve within 12 weeks in rabbit femurs. Subsequently, this material was applied to fracture fixation in humans, leading to tissue reactions as well.\textsuperscript{15} Rods made of blends such as polyglycolic -polylactic acid (PGAPLA) were also used in humans.\textsuperscript{45} Thus, in spite of all the research carried out up until now, all the above mentioned materials may still cause serious tissue reactions, when implanted subcutaneously, intra-articularly or in bone,\textsuperscript{7,8,10,15,16,22,45} depending on the place and the type and amount of the material.\textsuperscript{48} In addition, the resorption still takes such a long time that the implants, larger than small pins, may cause undesired wear of the opposite cartilage. Unless other materials are developed, they should not be used. If the refixation procedure eventually fails, several resurfacing procedures can be performed, such as perichondrium transplantation,\textsuperscript{47} mosaic plasty,\textsuperscript{28} an Osteochondral Auto Transplantation System procedure\textsuperscript{13} or cultured chondrocyte implantation.\textsuperscript{8,41} However, these procedures have their own disadvantages such as calcifications in the transplant or swelling and failure because of loosening and necrosis of the implants and should be regarded as a last resort. They are only indicated if the original fragment is too fragmented or not viable.

CONCLUSION

The study of the available literature and the results in our small series do not allow for a statistical analysis of the results of the different treatments of OCD, but do suggest that the optimal treatment of the non-detached juvenile OCD lesion (i.e. before closure of the physes) consists of arthroscopic drilling and fixation with a few biodegradable pins in order to add supplemental stability. When the fragment is dislocated, the situation equals to the displaced adult OCD lesion and replacement of the fragment and fixation under compression, after thorough debridement of the bed and transplantation of cancellous bone, currently seems to be the treatment of choice. Insertion of one metallic screw and a few biodegradable pins with a small diameter achieve compression and rotational stability, and causes less damage to the fragment than two screws. The screw has to be removed before loading the joint, in order to prevent erosions of the opposite cartilage surface. Biodegradable screws should rather not be used, because of the current implant-related disadvantages. Performing the procedure arthroscopically diminishes the additional trauma to the knee. If radiological healing occurs, but complaints persist, re-arthroscopy should be performed to debride residual cartilage irregularities, responsible for the symptoms.
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