Knee arthroplasty survival rate — either UKA or TKA — is currently 95%, greater than it was ten years ago, but has not been specifically evaluated in very active patients practicing sport at a high intensity.

The terms and conditions of return to physical activities are decided by the surgeon, the rehabilitation or Sports Medicine doctor, who needs to make sure that postoperative rehabilitation has been conducted optimally. Specifically, range of movement must be complete, muscular strengthening has to be sufficient and balance must be recovered by proprioception. Only after this stage (i.e. three to six months after surgery) can physical activities be resumed.

Return to sport must be gentle and progressive, with moderate activities limited to short sessions. Progressively the patient will be able to return to intermediate activities, provided that he/she possesses the adequate level of technique for the sport.

This up-to-date review for young surgeons and residents aims to provide an informative guide for patients regarding sport following knee arthroplasty.

Keywords: knee arthroplasty; return to sport; rehabilitation; patient information

Introduction

Total knee arthroplasty (TKA) confers significant mid- and long-term benefits for quality of life — particularly regarding pain and function — and is associated with a high level of satisfaction for the patient. While TKA is expected to increase by more than 670% by 2030, patients’ requirements and expectations have evolved towards being able to participate in recreational activities or sports following their knee surgery. Surgeons have long remained cautious, forbidding the practice of high-impact physical activities in order to prevent premature failure of implants. Such caution is nowadays being questioned, given the increasing functional demands desired by patients themselves, and with recent data from the literature bringing controversy to the debate. Indeed, implant integrity in physically active patients is reported not to be restricted.

Return to activity following knee arthroplasty – be it sports or other activities – is of concern to every patient. We know that practising physical activity from low to moderate intensity is safe, increasing standards of living through higher physical and social mobility and better cardiovascular performance. Furthermore, and from a public health perspective, this reduces costs related to treatments in this population. Some authors have even reported the benefits of knee arthroplasty to general health and sports performance. However, returning to sports activity after knee arthroplasty is not as well studied as other aspects of functional recovery. This review aims at raising awareness of the question of return to sports for TKA and unicompartmental knee arthroplasty (UKA) patients. Drawing on recent literature, this review seeks to identify factors which influence resumption of sports activity in order to guide patients using a more personalized approach.

Which factors influence return to sport?

Several elements influence return to sport after TKA. As this arthroplasty is not a replica of a healthy knee, it has its own limitations. Each patient has functional expectations
Return to sport after total or unicompartmental knee arthroplasty

and different resources which can lead to personalized objectives in terms of return to sporting activities.11

Implant design: TKA versus UKA

The impact of sports on prosthesis integrity is a crucial element to take into account. Cadaveric studies have confirmed the correlation between the intensity of the physical activity and wear rate for TKA, as well as between body weight and volumetric wear.5 These findings have further been verified by in vivo studies highlighting the adverse effects of some sports on implants, and emphasizing the importance of both surgical technique and the biomechanical properties of the bearing materials, especially polyethylenes.12–14 As these results are generally not considered in current practice, one should remain cautious and supervise the practice of physical activities after TKA. TKA remains superior to other prosthesis types in terms of functional results or implant wear rate.

One of the great advances in knee surgery is the management of unicompartmental arthritic damage by use of UKA (Table 1).1,15,18,21,22 For UKA, wear rate is a major long-term issue and represents one of the principal causes of failure.12,15 Again, implant wear can be reduced greatly by improving the design of polyethylene and by improving surgical techniques.16,17 The main limiting factor of return to sports remains the increased theoretical risk of wear and tear in young, active patients.

In terms of return to physical activities, Fisher et al18 report a 93% rate for UKA after successful rehabilitation, whereas Bradbury et al19 report only a 63% rate for TKA. Regarding the survival of UKAs, similar results were found compared with other arthroplasties, with an average survival rate of more than 90% after ten years.20–22 Price et al22 studied the influence of age on UKA survival and found a slightly lower rate of survival for patients under 60 years of age related to higher participation in activities and associated with a significant increase in functional scores. Studies evaluating UKA survival at long term are, however, still lacking. As a reminder, we note that in 1997 Diduch et al8 presented a series of 108 TKAs with a survival rate between 87% and 94% at 18 years follow-up, and in 2014 Long et al23 reported a survival rate of more than 80% at 25 years follow-up from the same series.

Several studies compared the functional results of unicompartmental prostheses with total knee prostheses from which we can summarize the following (Table 2): the rate of return to sports activities for UKAs is greater,24–26 as well as the postoperative performances,26 duration of sessions25 and the variety of activities.24 Regarding recovery time, results are overall mixed but seem to point toward a trend of faster recovery for UKAs compared with TKAs (about one month). Generally, return to light physical activities is achieved from the third month after surgery.

It seems that certain high impact sports are still practicable with a UKA.5,25 However, one should remain cautious as these studies have an insufficient perspective and do not allow us to draw a correlation between sustained physical activity and the long-term survival rates of implants.5,27,28 Finally, UKAs and TKAs relate to two different populations with different characteristics which influence return to sports and are tightly linked to the criteria of operative indications. On one hand, UKA patients are younger and more active due to the limited joint damage and function. On the other hand, TKA patients show

| Authors                  | Year  | Study                  | Follow-up | Series | Return to sport | Time to sport | Sport level | Sport time | Number of sports |
|--------------------------|-------|------------------------|-----------|--------|-----------------|---------------|------------|------------|-----------------|
| Argenson et al1          | 2002  | Retrospective study    | 66 mths   | 147 (160 UKA) | 94% at 10 years    |               |            |            |                 |
| Pennington et al21       | 2003  | Retrospective study    | 11 yrs    | 41 (46 UKA)  | 92% at 11 years    |               |            |            |                 |
| Price et al22            | 2005  | Comparative study      | 10 yrs    | 52 < 60 yrs | 91% at 10 years    |               |            |            |                 |
| Fisher et al18           | 2006  | Retrospective study    | 18 mths   | 76     | 96% at 10 years    | Return to sport: 93% |            |            |                 |
| Epinette et al15         | 2012  | Multicentre study      |           | 418 failed UKAs |                   | Revision: 19% at one year, 48.5% at five years | Etiology: loosening 45%; arthrosis 15%; wear 12%; technical failure 11.5% |

Table 1: Results of unicompartmental knee arthroplasty (UKA) in the recent literature

| Authors                  | Year  | Study                  | Follow-up | Series | Return to sport | Time to sport | Sport level | Sport time | Number of sports |
|--------------------------|-------|------------------------|-----------|--------|-----------------|---------------|------------|------------|-----------------|
| Witjes et al24           | 2017  | Systematic review, meta-analysis | TKA 3261 | 36% to 89% | 13 wks | 0.2 to 1            |               |            |            |                 |
|                          |       | UKA 662                |           | 75% to 100% | 12 wks | 11.1 to 4.2         |               |            |            |                 |
| Hopper and Leach25       | 2009  | Cohort study 22 mths   | TKA 76    | 34     | better         | shorter no difference | longer      |            |            |                 |
| Walton et al26           | 2006  | Cohort study 1 yr      | TKA 120  | better |                |                |            |            |                 |
|                          |       | UKA 150                |           | better |                |                |            |            |                 |

Table 2: Results of unicompartmental (UKA) and total knee arthroplasty (TKA) in recent comparative studies
greater comorbidity and less ambitious postoperative objectives in terms of functional recovery.24

**Patient-related factors**

Among the patient’s expectations, return to sports ranks variably (Table 3).5,7,19,32,33,35,38 The patient may be over-optimistic regarding the functional outcomes of the prosthesis resulting in a mismatch with the actual possible outcomes. This leads to higher dissatisfaction rates (about 20%) in patients with acceptable postoperative functional results.29,30 It is thus essential to identify the patient’s expectations before surgery in order to provide adequate information and prevent any inadequacy between these expectations and the possible results. Therefore, all patient-related factors which can affect return to sports must be identified during the postoperative examination.

**Age**

Younger patients have a higher functional demand and usually desire a quick return to physical activities. Generally, three out of four patients return to sports with a lower performance level, which results in lower satisfaction rates compared with older patients.31–33

**Motivation**

Patients’ motivation is a key element influencing several aspects of the return to sports such as recovery time, frequency of participation and performance level.34 We also know that younger patients are often the most motivated.35 Postoperative expectations to return to sport significantly condition the subjective postoperative results, but do not correlate with the objective results.11,36

**Postoperative sports practice**

Patients engaging in regular physical activities at a good level usually return more easily to sport after surgery.31 Certain sports, however, demand that the patient has had sufficient experience prior to the operation to be resumed postoperatively. Three out of four patients who practised physical activities one year prior to arthroplasty will return to sports but at a lower performance rate. Conversely, patients with no preoperative physical activities will not likely be able to start practising sport.7,19,37

**Body weight**

Being overweight and obesity are known risk factors associated with poor results in terms of satisfaction, functional results and return to sport.32 Furthermore, body weight affects polyethylene wear.12,33 Nevertheless, a higher functional gain for patients with normal body mass index is usually reported.

**Gender**

Male patients seem to show better postoperative results in terms of functional scores and activity rate,32,33,38 although these results are not universal.31

**Surgeon-related factors**

There is a sometimes a clear mismatch between the patient’s and the surgeon’s expectations in terms of functional results.35 The surgeon wishes to get activity and functional recovery which appears more satisfactory for the patient. Numerous surgeons tend to slow patients down in their will to return to ‘risky’ physical activities. It is, however, unrealistic to restrain a patient whose arthroplasty was motivated by the ambition of a return to sport.39 The surgeon therefore must help the patient to set the postoperative objectives within personalized yet realistic standards.

**Current recommendations in the literature review**

**The evidence regarding the influence of physical activity**

Current recommendations for return to sport after knee arthroplasty are reported in Table 4.42-44 Actually, the benefits of regular physical activity to health are irrefutable. Every patient who has indications for knee arthroplasty can gain benefits from physical activity after surgery. Data from the literature clearly demonstrate a reduction of risks of at least 20% to 30% of more than 25 chronic conditions and early mortality.42 We also know that older patients who remain active extend their functional independence.
Table 4: Current recommendations for return to sport after knee arthroplasty

| Authors                        | Year | Follow-up       | Results                                                                 |
|--------------------------------|------|-----------------|-------------------------------------------------------------------------|
| Jones42                         | 2011 | Review          | Low or intermediate intensity level of activity                         |
|                                |      |                 | Recovery time: 3 to 6 mths post-operatively                              |
|                                |      |                 | Discourage high-impact/violent sports                                   |
|                                |      |                 | Educate rather than deter patients                                      |
| Kuster and Stachowiak33         | 2002 | Review of literature | Bone quality benefits/implants’ fixation/limits unsealing               |
|                                |      |                 | Multi-weekly endurance activity                                         |
|                                |      |                 | Low-impact activity (cycling, swimming, walking)                        |
|                                |      |                 | High-load activity if practised at low intensity                        |
|                                |      |                 | Do not start a technically-demanding activity                           |
| Clifford and Mallon44           | 2005 | Review          | Slight benefit of sports to all patients                               |
|                                |      |                 | Light sports if balance recovery and proprioception                     |
|                                |      |                 | Intermediate sports if healthy and experienced patient                  |
|                                |      |                 | Discourage injury risk/violent sports                                  |

Physical activity and exercising should not be promoted in an isolated fashion, but should rather be addressed for each patient using a global approach aiming at improving performance.31

Return to sport in practice: how soon?
The minimum postoperative recovery time before returning to sports is three months.27 However, TKA patients return to sport on average after six months.37,38,40 Young, motivated patients return to sport more quickly. Low-intensity sports with low technical requirements can be resumed more quickly. In any case, return to sport must be progressive and in agreement with the surgeon, and must follow a well-conducted rehabilitation.15 The recovery time thus depends on the type of sport but also on patient-related factors such as age, motivation or the type of activities after surgery.

Return to sport in practice: which patients?
Every TKA patient will eventually resume physical activity.6 Postoperative rehabilitation must be sufficient in terms of muscular strengthening and proprioception. Some activities require the patient to have a special technical level in order to avoid difficulties.39 For patients with comorbidities, the terms of return to sport must be discussed with all the rehabilitation staff from the therapeutic care team and decided jointly.

Return to sport in practice: which sports?
Several studies have attempted to establish recommendations to rank the different types of sports activities.6,41 Usually, three categories of physical activities are defined for TKAs in ascending order: a) authorized recommended sports (walking, stationary bicycle, soft gymnastics, golf, swimming, dance, bowling, gardening); b) authorized sports with experience (road bike, hiking, skiing, doubles tennis, sailing, working out, rowing, canoeing); and c) unauthorized sports (football, basketball, handball, volleyball, jogging, singles tennis, racquetball, bouldering, gymnastics). This gradation underlines the need to have sufficient experience to practise sports at intermediate intensity. High-intensity sports must be advised against, although evidence of increased injury risks or mechanical complications (early damage, unsealing, periprosthetic fracture) is lacking. Sports with intermediate intensity can be authorized for a certain group of patients in good physical condition and with prior experience of these types of sports. Finally, low-intensity sports can be recommended for all patients— at least after sufficient recovery time—as soon as rehabilitation has been sufficient to regain balance and proprioception of the lower limb.6,7,39

Discussion
Few studies have focused on return to sport after knee arthroplasty. Surgeons have long advocated for the restriction and even the prohibition of certain sports activities without having scientific proof of the effect of sports on implant survival rate. To our knowledge, previous studies investigating the link between physical activity and wear are mostly experimental. These results were not found in clinical practice because series from the literature did not have sufficient hindsight to draw conclusions.5 Prosthesis survival rate— for either UKA or TKA— is currently 95%, greater than it was ten years ago, but has not been specifically evaluated in very active patients practising sport at a high intensity rate.9,20–22

According to studies from the Norwegian Arthroplasty Register, a higher risk of revision was found for male patients and for those aged younger than 65 years following TKA.45 For UKAs, patients aged younger than 65 years had also a higher risk of revision.45 This result is supported by the increasing incidence in younger TKA or UKA patients in the 2005 to 2015 period.45,46 TKA and UKA revisions resulting from aseptic loosening and polyethylene wear/breakage are related to younger patients with high-level activity and participation in contact sports. The use of more ‘patient-specific’ new materials in accordance with the level of physical activity may help to reduce the risk of loosening in younger patients. While implant design, surgical technique, polyethylene manufacturing and patient factors all influence the rate and volume of polyethylene wear, the use of highly cross-linked polyethylene (HXLPE) inserts in knee arthroplasty could improve wear rates according to promising short-term results.47 The increase in the use of HXLPE inserts in TKA is reported
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REFERENCES

1. Argenson JN, Boisgard S, Parratte S, et al. Survival analysis of total knee arthroplasty at a minimum 10 years’ follow-up: a multicenter French nationwide study including 846 cases. Orthop Traumatol Surg Res 2013;99:385-390.
2. Kurtz S, Ong K, Lau E, Mowat F, Halpern M. Projections of primary and revision hip and knee arthroplasty in the United States from 2005 to 2030. J Bone Joint Surg [Am] 2007;89-A:780-785.
3. Mancuso CA, Sculco TP, Wickiewicz TL, et al. Patients’ expectations of knee surgery. J Bone Joint Surg [Am] 2001;83-A:1005-1012.
4. Crowningshield RD, Rosenberg AG, Sporer SM. Changing demographics of patients with total joint replacement. Clin Orthop Relat Res 2006;443:266-272.
5. Jassim SS, Douglas SL, Haddad FS. Athletic activity after lower limb arthroplasty: a systematic review of current evidence. Bone Joint J 2014;96-B:923-927.
6. Clifford PE, Mallon WJ. Sports after total joint replacement. Clin Sports Med 2005;24:375-386.
7. Golant A, Christoforou DC, Slover JD, Zuckerman JD. Athletic participation after hip and knee arthroplasty. Bull NYU Hosp Jt Dis 2010;68:76-83.
8. Diduch DR, Insall JN, Scott WN, Scuderi GR, Font-Rodriguez D. Total knee replacement in young, active patients. Long-term follow-up and functional outcome. J Bone Joint Surg [Am] 1997;79:575-582.
9. Wright RJ, Sledge CB, Poss R, et al. Patient-reported outcome and survivorship after Kinemax total knee arthroplasty. J Bone Joint Surg [Am] 2004;86-A:2464-2470.
10. Chatterji U, Ashworth MJ, Lewis PL, Dobson PJ. Effect of total knee arthroplasty on recreational and sporting activity. ANZ J Surg 2005;75:405-408.
11. Noble PC, Gordon MJ, Weiss JM, et al. Does total knee replacement restore normal knee function? Clin Orthop Relat Res 2005;431:157-165.
12. Engh GA, Dwyer KA, Hanes CK. Polyethylene wear of metal-backed tibial components in total and unicompartamental knee prostheses. J Bone Joint Surg [Br] 1992;74-B:9-17.
13. Schmalzried TP, Shepherd EF, Dorey FJ, et al. The John Charnley Award. Wear is a function of use, not time. Clin Orthop Relat Res 2000;381:36-46.
14. Mintz L, Tsao AK, McCrae CR, Stulberg SD, Wright T. The arthroscopic evaluation and characteristics of severe polyethylene wear in total knee arthroplasty. Clin Orthop Relat Res 1991;273:215-222.

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Email: louisdagneaux@gmail.com
15. Epinette JA, Brunschweiler B, Mertl P, Mole D, Cazenave A, French Society for Hip and Knee. Unicompartmental knee arthroplasty modes of failure: wear is not the main reason for failure: a multicentre study of 418 failed knees. Orthop Traumatol Surg Res 2012;98(suppl):S124-S130.

16. Argenson JN, O’Connor JJ. Polyethylene wear in meniscal knee replacement. A one to nine-year retrieval analysis of the Oxford knee. J Bone Joint Surg [Br] 1992;74-B:228-232.

17. Psychoyios V, Crawford RW, O’Connor JJ, Murray DW. Wear of congruent meniscal bearings in unicompartmental knee arthroplasty: a retrieval study of 16 specimens. J Bone Joint Surg [Am] 1998,80-B:976-982.

18. Fisher N, Agarwal M, Reuben SF, Johnson DS, Turner PG. Sporting and physical activity following Oxford medial unicompartmental knee arthroplasty. Knee 2006;13:296–300.

19. Bradbury N, Barton D, Spoor G, Cross MJ. Participation in sports after total knee replacement. Am J Sports Med 1998;26:530-535.

20. Argenson JN, Chevrol-Benkeddache Y, Aubaniac JM. Modern unicompartmental knee arthroplasty with cement: a three to ten-year follow-up study. J Bone Joint Surg [Am] 2002;84-A:2235-2239.

21. Pennington DW, Swienckowski JJ, Lutes WB, Drake GN. Unicompartmental knee arthroplasty in patients sixty years of age or younger. J Bone Joint Surg [Am] 2003;85-A:1968–1973.

22. Price AJ, Dodd CF, Svard UGC, Murray DW. Oxford medial unicompartmental knee arthroplasty in patients younger and older than 60 years of age. Bone Joint J 2005; 87-B:1488-1492.

23. Long WJ, Bryce CD, Hollenbeck CS, Benner RW, Scott WN. Total knee replacement in young, active patients: long-term follow-up and functional outcome: a concise follow-up of a previous report. J Bone Joint Surg [Am] 2014;96-A:1759-1-7.

24. Witjes S, Gouttebarge V, Kuijer PPFM, et al. Return to sports and physical activity after total and unicompartmental knee arthroplasty: a systematic review and meta-analysis. Sports Med 2016;46:269-292.

25. Hopper GP, Leach WJ. Participation in sporting activities following knee replacement: total versus unicompartmental. Knee Surg Sports Traumatol Arthrosc 2008;16:973-979.

26. Walton NP, Jahromi I, Lewis PL, et al. Patient-perceived outcomes and return to sport and work: TKA versus mini-incision unicompartmental knee arthroplasty. J Knee Surg 2008;19:112-116.

27. Naal FD, Fischer M, Preuss A, et al. Return to sports and recreational activity after unicompartmental knee arthroplasty. Am J Sports Med 2007;35:1688-1695.

28. Pietstchmann MF, Wohlleb L, Weber P, et al. Sports activities after medial unicompartmental knee arthroplasty Oxford III—what can we expect? Int Orthop 2013;37:31-37.

29. Husain A, Lee G-C. Establishing realistic patient expectations following total knee arthroplasty. J Am Acad Orthop Surg 2015;23:707-713.

30. Bourne RB, Chesworth BM, Davis AM, Mahomed NN, Charron KD. Patient satisfaction after total knee arthroplasty: who is satisfied and who is not? Clin Orthop Relat Res 2010;468:57-63.

31. Kersten RF, Stevens M, van Raay JIAM, Bulstra SK, van den Akker-Scheek I. Habitual physical activity after total knee replacement. Phys Ther 2012;92:709-716.

32. Williams DH, Greidanus NV, Masri BA, Duncan CP, Garbuz DS. Predictors of participation in sports after hip and knee arthroplasty. Clin Orthop Relat Res 2002;400:555-561.

33. Iorio R, Healy WL, Applegate T. Validity of preoperative demand matching as an indicator of activity after TKA. Clin Orthop Relat Res 2006;452:44-48.

34. Weiss JM, Noble PC, Condit MA, et al. What functional activities are important to patients with knee replacements? Clin Orthop Relat Res 2002;400:172-188.

35. Bonnin M, Laurent JR, Parratte S, et al. Can patients really do sport after TKA? Knee Surg Sports Traumatol Arthrosc 2010;18:853-862.

36. Bullens PH, van Loon CJ, de Waal Malefijt MC, Laan RF, Veth RP. Patient satisfaction after total knee arthroplasty: a comparison between subjective and objective outcome assessments. J Arthroplasty 2001;16:740-747.

37. Wylde V, Blom A, Dieppe P, Hewlett S, Learmonth I. Return to sport after joint replacement. J Bone Joint Surg [Br] 2008;90-B:920-923.

38. Dahm DL, Barnes SA, Harrington JR, Sayer SA, Berry DJ. Patient-reported activity level after total knee arthroplasty. J Arthroplasty 2008;23:401-407.

39. Swanson EA, Schmalzried TP, Dorey FJ. Activity recommendations after total hip and knee arthroplasty: a survey of the American Association for Hip and Knee Surgeons. J Arthroplasty 2009;24(suppl):120-126.

40. Lavermia CJ, Sierra RJ, Hungerford DS, Krackow K. Activity level and wear in total knee arthroplasty: a study of autopsy retrieved specimens. J Arthroplasty 2001;16:446-453.

41. Healy WL, Sharma S, Schwartz B, Iorio R. Athletic activity after total joint arthroplasty. J Bone Joint Surg [Am] 2008;90-A:2245-2252.

42. Jones DL. A public health perspective on physical activity after total hip or knee arthroplasty for osteoarthritis. Phys Sportsmed 2011;39:70-79.

43. Kuster MS, Stachowiak GW. Factors affecting polyethylene wear in total knee arthroplasty. Orthopedics 2002;25(suppl):5235-5242.

44. Clifford PE, Mallon WJ. Sports after total joint replacement. Clin Sports Med 2005;24:775-186.

45. Dyrhovden GS, Lygre SHL, Badawy M, Gothenes Ø, Furnes O. Have the Causes of Revision for Total and Unicompartmental Knee Arthroplasties Changed During the Past Two Decades? Clin Orthop Relat Res 2017;475:1874-1886.

46. Niemeläinen MJ, Mäkelä KT, Robertsson O, et al. Have the Past Two Decades? Clin Orthop Relat Res 2017;475:1874-1886.

47. Bonnin M, Laurent JR, Parratte S, et al. Can patients really do sport after TKA? Knee Surg Sports Traumatol Arthrosc 2010;18:853-862.

48. Weiss JM, Noble PC, Condit MA, et al. What functional activities are important to patients with knee replacements? Clin Orthop Relat Res 2002;400:172-188.

49. Bourne RB, Chesworth BM, Davis AM, Mahomed NN, Charron KD. Patient satisfaction after total knee arthroplasty: who is satisfied and who is not? Clin Orthop Relat Res 2010;468:57-63.

50. Kersten RF, Stevens M, van Raay JIAM, Bulstra SK, van den Akker-Scheek I. Habitual physical activity after total knee replacement. Phys Ther 2012;92:709-716.

51. Williams DH, Greidanus NV, Masri BA, Duncan CP, Garbuz DS. Predictors of participation in sports after hip and knee arthroplasty. Clin Orthop Relat Res 2002;400:555-561.

52. Iorio R, Healy WL, Applegate T. Validity of preoperative demand matching as an indicator of activity after TKA. Clin Orthop Relat Res 2006;452:44-48.

53. Weiss JM, Noble PC, Condit MA, et al. What functional activities are important to patients with knee replacements? Clin Orthop Relat Res 2002;400:172-188.