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Microfracture for knee chondral defects: a survey of surgical practice among Canadian orthopedic surgeons

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Abstract
Purpose The purpose of this study was to describe the practice of microfracture surgery for knee chondral defects among Canadian orthopedic surgeons.
Methods All orthopedic surgeon members of the Canadian Orthopaedic Association were invited to participate in a survey, designed to explore the microfracture technique used by orthopedic surgeons in the treatment for knee chondral defects The primary outcome measure was an emailed 26-item questionnaire, which explored indications for microfracture surgery, surgical techniques, types of postoperative rehabilitation regimes used and assessment of outcome. In addition, responses were compared between orthopedic surgeons with a sports medicine practice to surgeons with a non-sports medicine practice.
Results The survey response rate was 24.6% (299/1,216), with 131 regularly performing microfracture. 41% of surgeons indicated that they had no upper limit for age at the time of surgery, and 87% indicated no upper limit for body mass index. The majority of respondents (97%) resected cartilage back to a stable margin, while 69% of respondents removed the calcified cartilage layer prior to creating holes. Only 11% of respondents used continuous passive motion (CPM) postoperatively, and 39% did not restrict weight bearing. Sports surgeons were more likely than non-sports surgeons to remove the calcified cartilage layer, use a 45° pick, use CPM and restrict weight bearing postoperatively (all P values < 0.05).
Conclusions This survey on microfracture for knee chondral defects revealed widespread variation among surgeons regarding the indications for surgery, surgical technique, postoperative rehabilitation and assessment of outcome. Sports surgeons demonstrate better evidence-based practice than non-sports surgeons for a few important parameters.
Level of evidence Cross-sectional survey, Level II.

Keywords Microfracture · Chondral defects · Knee · Questionnaire · Indications

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Introduction

Chondral injuries of the knee pose a considerable challenge because the intrinsic regeneration capacity of articular cartilage is limited [6, 7, 21]. Several techniques such as microfracture, autologous chondrocyte implantation (ACI) and mosaicplasty have been described for the management

of chondral defects. Since Steadman first described it in the 1980s, microfracture has become popular as a first-line treatment for chondral injuries [32]. The underlying principle of the microfracture technique is bone marrow stimulation and penetration of the subchondral bone plate resulting in the recruitment of mesenchymal stem cells which eventually differentiate into fibrocartilage [4, 38].

As a technique, microfracture has several advantages compared to other techniques. It is technically easier to perform and relatively inexpensive. Compared to ACI and autologous cartilage transplantation, microfracture avoids donor site morbidity and is a single stage procedure. In a randomized comparison of microfracture with ACI, microfracture patients had similar Tegner scores at 2 and 5 years, with reduced reoperation rates [17, 18]. However, a similar comparison of MACI with microfracture demonstrated improved Tegner and Lysholm scores over 2 years in the MACI treatment group [2]. A recent Cochrane review of autologous chondrocyte implantation in the knee determined that there was insufficient evidence at this time to draw conclusions [36].

There are some limitations of the microfracture technique. Normal articular cartilage is composed of hyaline cartilage, containing predominantly type-II collagen. Microfracture results in a regenerate that is predominantly fibrocartilage, containing a higher proportion of type-I than type-II collagen [5, 13, 14, 17, 23]. Since hyaline cartilage is loaded in compression, whereas fibrocartilage is loaded in tension, fibrocartilage is not biomechanically adapted to serve as articular cartilage [9]. Over time, it has been shown that the initial benefit of microfracture tends to decline between 18 and 36 months after surgery, but despite this deterioration, postoperative functional scores remain higher than preoperative scores [4, 13–15, 19, 20, 24, 25]. Long-term studies demonstrate improved knee function in 67% to 86% of patients at an average of 6–7 years after microfracture [2, 12, 13, 30, 33].

With microfracture, the yield of stem cells is quite low, resulting in a low fill volume of chondral defects; animal studies demonstrate that stem cell yield declines with advancing age [35] and that techniques such as mosaicplasty result in significantly higher degrees of tissue filling than microfracture [16]. This may explain why significantly better results are seen in patients under the age of 40 years [19] and in defects smaller than 2 cm^2 [15]. Attempts to improve defect filling following microfracture with hyaluronic acid injections in rabbits has shown some promise, but requires further study [34].

Although microfracture is technically less demanding, there are still a number of critical steps that must be performed to achieve a successful outcome. Studies have shown that achieving a stable clot with maximal fill volume of the chondral defect and removal of the calcified cartilage layer are associated with better outcomes [10, 11]. In the absence of a healthy cartilaginous rim, containment of the blood clot proves difficult [1, 25, 26]. Removal of the calcified cartilage layer from the base of the lesion is also a critical step, as it aids clot adhesion [11]. Finally, microfracture holes must be of sufficient depth to penetrate the subchondral plate and enter the marrow cavity; visualization of fat droplets in the joint can confirm this.

After microfracture, a strict postoperative protocol has been advocated. According to the rehabilitation protocol of Steadman, patients are prescribed continuous passive motion (CPM) immediately in the recovery room for 6–8 h every 24 h and only touch weight bearing allowed for the first 6 weeks after surgery [30]. The rationale for CPM is that motion improves cartilage nutrition and stimulates mesenchymal stem cell differentiation [27, 37]. The postoperative rehabilitation protocol has been reported to be a critical component in the overall success of the microfracture technique [28, 31].

Although the technique of microfracture is well described, there may be substantial variation in the practice of microfracture for knee chondral defects. If differences exist in patient selection, surgical technique and postoperative rehabilitation, this may affect the outcome of surgery. The objective of this study was to investigate this variation in a systematic manner. The hypothesis is that there will be a wide variation in practice, with differences seen between surgeons specializing in arthroscopy and sports medicine compared to surgeons subspecialized in other fields.

Materials and methods

A clinical question was asked whether variation exists among orthopedic surgeons as to their practice in the performance of microfracture for chondral injuries of the knee. As a first step, key words were selected to assist in the performance of a literature review to determine factors known to affect the outcome of microfracture technique. A computerized search of the Medline database through PubMed was undertaken, using the keywords "microfracture," "microfracture surgery" and "microfracture knee" limited to English articles, up until November 2011. After the Medline search was completed, all abstracts were reviewed independently by the authors, with the identification of clinical research studies published in the peer-reviewed journals. Articles demonstrating patient and technical factors affecting the outcome of microfracture surgery were obtained in full and evaluated; a list of factors which have been demonstrated to be linked to outcome in microfracture surgery were compiled and are listed in Table 1.

Using these data as a guide, a questionnaire was generated in order to evaluate the microfracture practice

Table 1 Factors predicting a better outcome for microfracture surgery based on a review of the literature

Factors	Better outcome with
Age	<40 years [14, 17–20, 24, 25]
Lesion size	<4 cm^2 [15, 17]
BMI	<30 kg m^2 [24]
Preoperative activity level	Tegner score >4 [4, 17, 25]
Previous surgery	Primary surgery [12, 25]
Calcified Cartilage Layer	Removal [10, 11]
Cartilage Margin	Resection to stable margin [1, 25, 26]
Repair cartilage volume	Good fill volume (>66%) [10, 11]

patterns of Canadian orthopedic surgeons. Indications for and limitations of microfracture, including patient age, BMI, site of the chondral defect, as well as the use of pre- and postoperative knee scores, were investigated. Surgeons were also asked to consider whether they would perform revision microfracture. The surgical technique was assessed in detail, including instruments used, as well as the specific depth and separation of holes created. Focus was also on postoperative care, including the use of CPM, weight bearing status and postoperative imaging, as well the perceived success of the technique.

The initial questionnaire was refined using a test group of orthopedic surgeons specializing in sports medicine. This pretest group resulted in a generation of new questions and reduction of questions felt not relevant in addressing the clinical hypothesis. These were reviewed, questions ranked on relevance, and final changes considered appropriate were incorporated into the questionnaire. The Canadian Orthopaedic Association (COA) was chosen as the sample group. This group was chosen based on the accessibility of contact information, as well as the hope that a survey conducted by surgeons from the same national society would result in a higher response rate. The COA was contacted, and a list of current members was obtained. The final questionnaire was sent to all COA members via email, and the survey was completed via the web using Survey Monkey (http://www.surveymonkey.com). Two reminders were sent to complete the questionnaire over a 4-week time frame. Only questionnaires filled out by surgeons regularly performing microfracture of the knee were included in the analysis.

Statistical analysis

Completed questionnaires were analyzed to determine the similarities and differences in the practice of microfracture. All statistics were generated using SPSS (version 12.0; SPSS, Chicago, IL). Student's t test statistics were used for differences in continuous data. Chi-square analysis was used to examine the differences when answers were categorical. A P value <0.05 was set as statistically significant. Additionally, the responses provided by surgeons with a sports medicine practice were compared with those of surgeons with a non-sports medicine practice.

Results

Of the 1261 questionnaires sent, 32 opted out of the survey, and 13 requests failed due to incorrect email addresses. Therefore, a total of 1,216 email invitations were sent out for the survey. 299 responses were received, giving a response rate of 24.6%. 131 surgeons (43.8%) confirmed that they regularly perform microfracture of the knee. The practice areas of these surgeons are seen in Fig. 1.

Indications for surgery

The age limits for performing microfracture of the knee and knee cartilage defects surgeons were willing to microfracture are seen in Figs 2 and 3. Regarding body mass index (BMI), 87% ($n = 114$) of surgeons reported no upper limit for BMI when performing microfracture. Seventeen surgeons reported an upper limit for BMI; the average response was a BMI of 35.12, although wide variation was noted with a range from 27 to 45. Eleven surgeons out of 115 indicated that they used a preoperative knee scoring system, out of which 10 stated that it influenced their decision on whether to perform the procedure or not. A small number of surgeons were prepared to undertake revision microfracture (30%, $n = 39$).

Surgical technique

The majority of respondents (97%, $n = 126$) indicated that they resected cartilage back to a stable margin prior to performing microfracture. Prior to creating holes in the bone, only 69% ($n = 90$) of surgeons indicated that they removed the calcified cartilage layer. Instrument choices are seen in Fig. 4. The majority of surgeons (80%, $n = 105$) expressed confidence in being able to create holes 3–4 mm apart, and the majority of surgeons visualized the appearance of fat droplets in the knee joint after creating their holes (78%, $n = 102$). Almost half the respondents (50%, $n = 65$) washed the knee joint out after performing microfracture.

Postoperative regime

The vast majority of respondents (89%, $n = 117$) indicated that they do not use CPM as part of their postoperative regime. Significant variation was also noted in postoperative weight bearing status (Fig. 5).

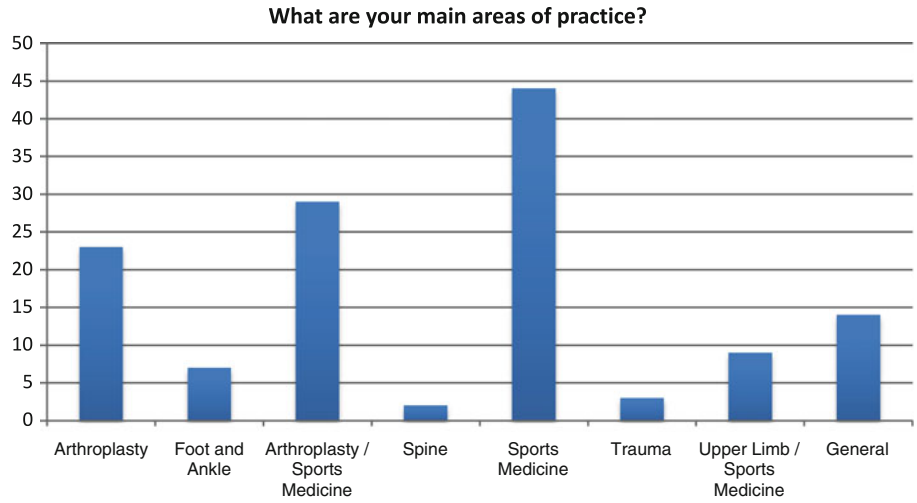

Fig. 1 Principle practice areas of respondents regularly performing microfracture ($N = 131$)

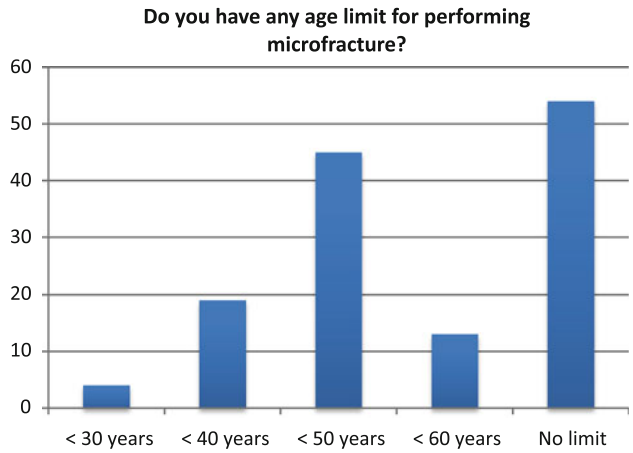

Fig. 2 Age limit for performing microfracture of the knee ($N = 131$)

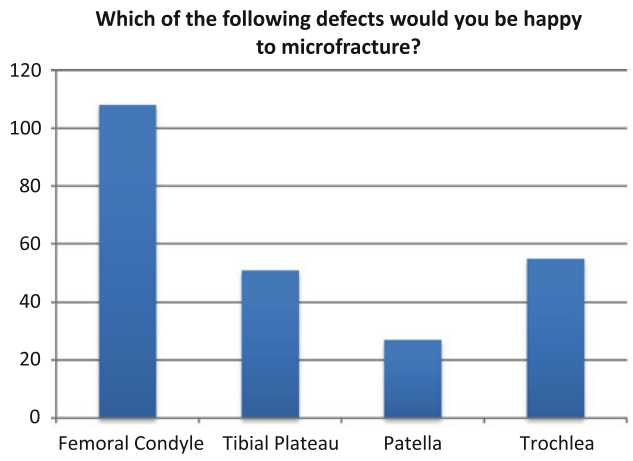

Fig. 3 Defects of the knee that respondents are happy to microfracture ($N = 131$)

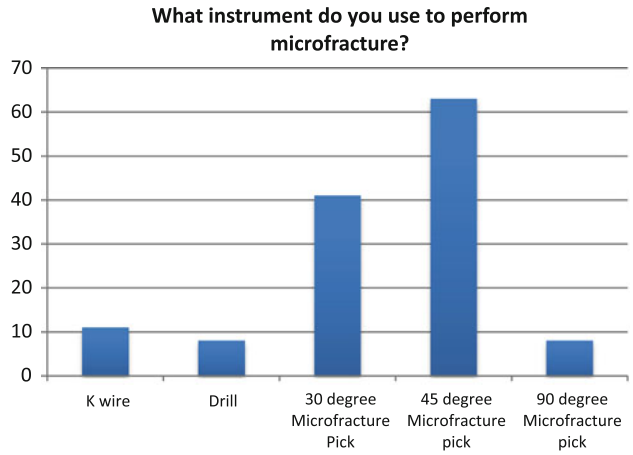

Fig. 4 Choice of instrument for microfracture ($N = 131$)

Outcome

Only five surgeons indicated that they used a postoperative scoring system to assess outcome; three surgeons used the IKDC system, and one surgeon used KOOS and the Noyes system, respectively. The overall impression of success of microfracture and the length of benefit from microfracture is detailed in Figs 6 and 7. A large number of surgeons (58%, $n = 76$) felt that other techniques for cartilage regeneration, such as autologous cartilage implantation, mosaicplasty and osteochondral allograft, offered advantages over microfracture.

Differences between sports surgeons and non-sports surgeons

The results were analyzed to look for differences in practice between surgeons who indicated that they are specialized

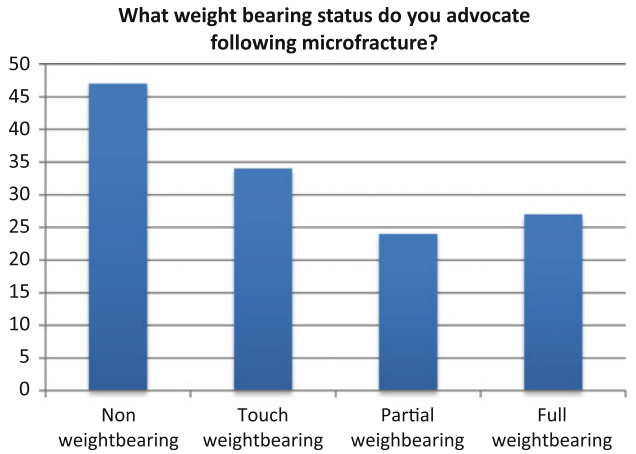

Fig. 5 Postoperative weight bearing status after microfracture ($N = 131$)

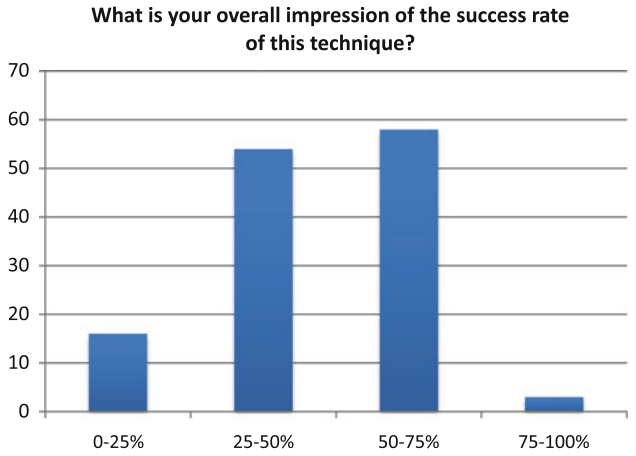

Fig. 6 Respondents impression of the success rate of microfracture of the knee ($N = 131$)

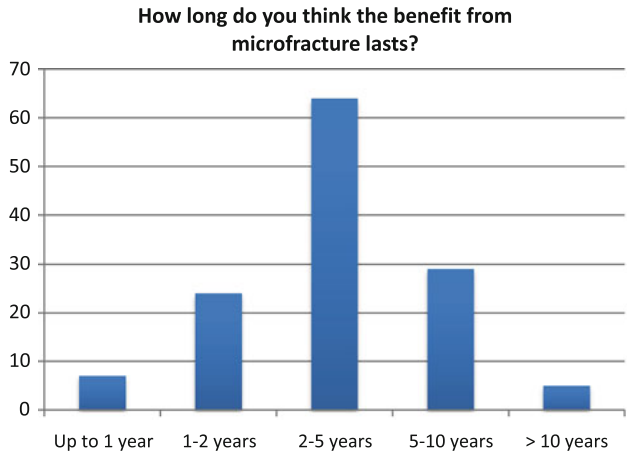

Fig. 7 How long respondents felt the benefit of microfracture lasts ($N = 131$)

Table 2 Variables with a statistically significant difference between sports and non-sports surgeons

Variable	Sports surgeons ($n = 82$)	Non-sports surgeons ($n = 49$)	P value
Remove calcified cartilage	65	27	0.005
Use 45 degree pick	46	17	0.02
Wash out knee at end of surgery	33	31	0.012
Use CPM	13	1	0.017
Restrict weight bearing after surgery	59	20	0.001

in sports medicine and other orthopedic surgeons. Statistically significant differences in practice are listed in Table 2.

Discussion

The most important finding of the present study is that a significant number of surgeons are not performing important steps of microfracture technique and are perhaps not aware of factors known to affect outcome such as age and BMI.

Microfracture of the knee is a commonly performed surgical procedure. Its appeal lies in the fact that it can be performed quickly, is inexpensive and not technically demanding. However, review of the literature suggests that in order to achieve optimal results, surgeons must rigidly adhere to well-advocated principles governing indications for surgery, surgical technique and postoperative rehabilitation [3].

This study revealed that thirty-one percent of surveyed surgeons regularly performing microfracture surgery do not remove the calcified cartilage layer prior to creating holes, a known factor affecting outcome [10, 11]. It should, however, be noted that sport surgeons demonstrated better compliance for removing the calcified cartilage layer compared to non-sports surgeons ($P < 0.05$).

Many studies have shown that younger age results in better outcomes following microfracture [14, 17, 18, 20, 24, 25]. These studies have shown an upper age threshold between 30 and 40 years. However, in this survey, 41% of surgeons indicated that they had no upper age limit for performing microfracture, while 34% indicated an upper age limit of 50 years. It may appear that the opinions from the survey do not take current evidence into account; however, many surgeons may still attempt microfracture in patients over 40 years of age, given the lack of other easily performed and cost-effective alternatives. While microfracture gives best results in patients under the age of 40 years, an upper age

limit beyond which microfracture confers little or no benefit has not been established. This evidence would be required prior to a rigid upper age limit being applied.

A BMI > 30 kg/m^2 has also been reported to correlate with an inferior outcome after microfracture [24]. Hence, it is surprising to note that in this survey, 88% of surgeons reported no upper limit of BMI for performing microfracture. Of the 17 surgeons, who reported an upper limit, the average BMI value was 35.12 kg/m^2 $\pm$ 6.3 (range, 27–45 kg/m^2). The inference from this is that the upper BMI limit given by respondents was not necessarily backed by strong evidence. It would certainly seem logical to establish a BMI value beyond which microfracture should not be attempted.

Previous studies have shown that higher preoperative Tegner scores are associated with higher postoperative knee scores and better postoperative athletic ability [4, 17, 25]. Only 11 responding surgeons indicated that they used a preoperative scoring system, and none used the Tegner system. The use of scoring systems allows for a more objective opinion to be formed regarding the efficacy of a particular surgical procedure. However, although higher preoperative scores are likely to result in higher postoperative scores, this does not in itself preclude surgery for patients with lower preoperative scores. Furthermore, even if patients with low preoperative scores are found to have low postoperative scores, they may still be very happy with the results of their treatment. Therefore, it is difficult to advocate routine use of preoperative scoring systems on which to base treatment decisions.

Only 30% of surgeons were prepared to consider revision microfracture. This is in keeping with literature that confirms that microfracture tends to work best as a primary procedure [12, 25]. This survey also revealed several variations in surgical practice, for which clear evidence is lacking. For example, there is no strong evidence to confirm which type of instrument should be used to create the bone holes. While the majority of surgeons used the 33° or 45° awl, no information was obtained regarding whether instrument selection varied depending on the anatomical location of the defect. Five percent of the respondents indicated that they use a drill, and 8% use a K-wire to create holes in the subchondral surface; again no information is available regarding whether either device was preferred for a specific anatomical location. Clearly, using a drill or K-wire in certain regions of the knee such as the patella is more difficult.

Interestingly, a recent animal study has shown that the microscopic structure of holes created by a microfracture awl and a drill differs [8]. In this study, limited to a time point of 1 day postoperatively and assessed in two rabbits, microfracture was found to produce fractured and compacted bone around the holes, essentially sealing them off from viable bone marrow and potentially impeding repair. In contrast, drilling cleanly removed bone from the holes, providing a better access channel to marrow stroma. Hence, it may actually be that the 5% of the surgeons using a drill are employing the correct technique, particularly if sclerotic bone is encountered. However, further evidence is required before any firm recommendations can be made.

Almost half (49%) of the respondents washed out the knee joint after performing microfracture. Clear evidence is lacking on whether this is beneficial or detrimental by way of dislodging any forming clot. However, it seems that sports medicine surgeons are more cautious of washing the joint out at the end of the procedure than non-sports surgeons ($P < 0.012$).

The postoperative regime after microfracture remains one of the most debated issues with regard to this technique. Patient compliance with restricted weight bearing is a significant problem, and gaining access to a CPM machine is also a problematic issue in many healthcare systems. This survey indicates that sports surgeons more commonly advocate restricted weight bearing after surgery than non-sports surgeons ($P = 0.001$). Not surprisingly, 89% of surgeons did not use CPM as a rehabilitation modality after microfracture surgery. While sports surgeons indicated CPM use more often than non-sports surgeons ($P < 0.05$), overall CPM use was low even among sports surgeons. Although the benefit of motion and mechanical stimulation on cartilage nutrition and mesenchymal stem cell differentiation has been established, it is not clear whether this translates into a discernable clinical benefit [27, 29, 37]. CPM has been shown to significantly improve the macroscopic grading of treated defects [25]. However, in a case–control study of small femoral condyle defects <2 cm^2, CPM was not found to result in a significant difference in outcome between the 2 groups [22]. Therefore, while the postoperative regime remains contentious, strong recommendations cannot be made, and there is need to perform high-quality randomized controlled trials.

A limitation of this study was the relatively low response rate. Of a total of 1,216 emails sent, 299 responses were received (24.6%). Of these, 131 (43.8%) confirmed that they regularly perform microfracture of the knee. Exact figures for the number of orthopedic surgeons performing knee arthroscopy in Canada is not known; it is therefore likely that this study cannot comment on the practice patterns of all surgeons regularly performing microfracture.

This survey has clinical relevance, by highlighting that further research is required in order to establish best practice on how to perform microfracture, especially in regard to surgical indications, technique and postoperative rehabilitation. In this way strong, evidence-based recommendations can be made to surgeons performing this technique.

Conclusion

Microfracture for knee chondral defects is a technique that has widespread variation among surgeons regarding the indications for surgery, surgical technique, postoperative rehabilitation and assessment of outcome. Sports surgeons demonstrate better evidence-based practice than non-sports surgeons for a few important parameters.

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