

## Venous Thromboembolism in Lower Extremity Arthroscopy

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**Abstract:** Venous thromboembolism (VTE) is a relatively rare complication of arthroscopic surgery of the lower extremity, but it does have the potential to result in significant morbidity and possible mortality. VTE has been reported to occur with knee arthroscopy, and guidelines for VTE prophylaxis before and after knee arthroscopy have been proposed. There are much fewer data regarding the incidence of VTE occurring after arthroscopy of the ankle and the hip. This article reviews the literature on the incidence, treatment, and prevention of VTE in association with arthroscopy of the lower extremity. **Key Words:** Arthroscopy—Deep venous thrombosis—Lower extremity—Prophylaxis—Pulmonary embolism—Venous thromboembolism.

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Arthroscopy has long been perceived as low-risk surgery relative to other areas of orthopaedics, such as total joint replacement and trauma.<sup>1-3</sup> Reported rates of venous thromboembolism (VTE) in association with lower extremity arthroscopy range from 0% to 17.9%. However, reported rates of pulmonary embolism (PE) and deep venous thrombosis (DVT) associated with total joint replacement in the absence of prophylaxis have approached 30% and 70%, respectively.<sup>2</sup> Anticoagulation prophylaxis improves the incidence to approximately 0% for PE and 1.5% for DVT, but VTE still remains a major concern for every arthroscopic surgeon.

Considerable controversy exists within the orthopaedic community regarding prophylaxis of VTE in patients undergoing total joint replacement. Multiple

studies have been performed within this population, each with its own recommendations. The Seventh American College of Chest Physicians (ACCP) Conference on Antithrombotic and Thrombolytic Therapy performed an in-depth meta-analysis of these voluminous data and published guidelines for care.<sup>4</sup> However, these data nevertheless remain controversial.<sup>5-7</sup> The American Academy of Orthopaedic Surgeons (AAOS) has also established its own guidelines for the prevention of VTE in total joint arthroplasty of the hip and knee.<sup>8</sup> VTE in arthroscopic surgery has not garnered the same level of concern, yet it remains an important cause of morbidity and even reported cases of mortality. This article reviews the relevant literature on VTE associated with lower extremity arthroscopy.

### HIP ARTHROSCOPY

In a review article regarding hip arthroscopy published 20 years ago, Hawkins<sup>9</sup> warned that “systemic complications, such as pulmonary emboli, must always be considered.” In multiple series of hip arthroscopy cases published in the past 2 decades, however, PE or DVT has simply not been reported. No currently published study has specifically focused on this issue, but a review of more than 5,500 cases in the literature has revealed a 0% rate of DVT and PE (Table 1).<sup>10-36</sup>

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**TABLE 1.** *Reported Incidence of Venous Thromboembolism in Hip Arthroscopy*

Author	Year	No. of Patients	DVT/PE Rate
Glick et al. <sup>10</sup>	1987	12	0%
Small <sup>11</sup>	1988	14	0%
Funke and Munzinger <sup>12</sup>	1996	19	0%
Byrd and Chern <sup>13</sup>	1997	11	0%
Baber et al. <sup>14</sup>	1999	328	0%
Griffin and Villar <sup>15</sup>	1999	640	0%
Byrd and Jones <sup>16</sup>	2000	38	0%
McCarthy et al. <sup>17</sup>	2001	436	0%
Dienst et al. <sup>18</sup>	2001	35	0%
O'Leary et al. <sup>19</sup>	2001	86	0%
Sampson <sup>20</sup>	2001	530	0%
Byrd <sup>21</sup>	2003	265	0%
Clarke et al. <sup>22</sup>	2003	1,054	0%
Keeney et al. <sup>23</sup>	2004	102	0%
McCarthy <sup>24</sup>	2004	1,475	0%
Pasa et al. <sup>25</sup>	2005	24	0%
Yamamoto et al. <sup>26</sup>	2005	10	0%
Yamamoto et al. <sup>27</sup>	2005	30	0%
Awan and Murray <sup>28</sup>	2006	22	0%
Lo et al. <sup>29</sup>	2006	73	0%
Jerosh et al. <sup>30</sup>	2006	22	0%
Mullis and Dahners <sup>31</sup>	2006	36	0%
Owens and Busconi <sup>32</sup>	2006	11	0%
Bushnell et al. <sup>33</sup>	2007	156	0%
Kim et al. <sup>34</sup>	2007	43	0%
Philippon et al. <sup>35</sup>	2007	45	0%
Philippon et al. <sup>36</sup>	2007	37	0%
Total	—	5,554	0%

Abbreviations. DVT, deep venous thrombosis; PE, pulmonary embolism.

Specific recommendations for prophylaxis of VTE in hip arthroscopy have not been reported. Numerous authors have discussed VTE prophylaxis in other surgical procedures of the hip, but applying these data to hip arthroscopy is inappropriate because of fundamental differences in the type of surgical procedures and in the patient populations. Rather than emphasizing the arthroscopic procedure itself as a risk factor, the surgeon should instead focus on factors related to the patient's medical history and current medical condition. Most of these risk factors have been well described throughout the medical and surgical literature (Table 2). Decisions regarding anticoagulation prophylaxis for hip arthroscopy should be made on an individualized patient basis and documented in the medical record.

## ANKLE ARTHROSCOPY

As in hip arthroscopy, ankle arthroscopy has a low rate of VTE. While not specific for ankle ar-

throscopy, a 0.2% to 4% incidence of VTE has been reported in association with all types of foot and ankle surgery.<sup>37-39</sup> A review of recent literature specific for ankle arthroscopy confirms that this very low incidence rate can indeed be extrapolated to arthroscopic ankle surgery. In 15 studies involving more than 1,300 patients total, no DVT or PE was reported (Table 3).<sup>40-54</sup>

Three particular studies of VTE in ankle surgery in general merit discussion in light of their relevance to arthroscopic ankle surgery. Mizel et al.<sup>37</sup> performed a prospective, multicenter analysis of the rate of VTE in 2,373 patients undergoing various procedures of the foot and ankle. They reported a 0.22% incidence of VTE, including a 0.15% rate of non-fatal pulmonary embolus. Patients were diagnosed by clinical examination alone. The authors found that postoperative immobilization and non-weight-bearing status statistically correlated with an increased risk of VTE. They also performed a cost-benefit analysis of screening tests and prophylaxis for VTE, and they concluded that neither is justified in routine clinical care.

Solis and Saxby<sup>38</sup> published a prospective study in which 201 consecutive patients undergoing general foot and ankle surgery received duplex ultrasound testing. No prophylaxis for VTE was used in any of

**TABLE 2.** *General Risk Factors for Venous Thromboembolism*

Advanced age
Personal or family history of previous deep venous thrombosis or pulmonary embolism
Major systemic trauma
Lower extremity trauma
Prolonged immobilization
Full or partial paralysis of lower extremities
Central venous catheterization
Obesity
Tobacco use
Cancer
Pregnancy or postpartum status
Hormonal contraceptive use
Hormone replacement therapy
Treatment with selective estrogen receptor modulators
Known thrombophilic condition
Varicose veins
Acute medical illness
Heart failure
Respiratory failure
Inflammatory bowel disease
Myeloproliferative disorders
Nephrotic syndrome
Paroxysmal nocturnal hemoglobinuria

**TABLE 3.** *Reported Incidence of Venous Thromboembolism in Ankle Arthroscopy*

Author	Year	No. of Patients	DVT/PE Rate
Van Dijk et al. <sup>40</sup>	1996	30	0%
Harrington et al. <sup>41</sup>	1996	24	0%
Acevedo et al. <sup>42</sup>	2000	29	0%
Rasmussen et al. <sup>43</sup>	2002	105	0%
Ono et al. <sup>44</sup>	2004	105	0%
Hintermann et al. <sup>45</sup>	2004	51	0%
Thomas et al. <sup>46</sup>	2005	50	0%
Nihal et al. <sup>47</sup>	2005	11	0%
Maiotti et al. <sup>48</sup>	2005	22	0%
Ferkel et al. <sup>49</sup>	2005	35	0%
Okuda et al. <sup>50</sup>	2005	30	0%
Lui et al. <sup>51</sup>	2006	5	0%
Savva et al. <sup>52</sup>	2007	808	0%
Collman et al. <sup>53</sup>	2007	39	0%
Hassan <sup>54</sup>	2007	23	0%
Total	—	1,367	0%

Abbreviations. DVT, deep venous thrombosis; PE, pulmonary embolism.

these patients. Deep calf vein thrombi were diagnosed in 7 patients, representing a 3.5% incidence rate. The authors concluded that postoperative immobilization, surgery of the hindfoot, increased tourniquet time, and advanced age all were risk factors for VTE.

Hanslow et al.<sup>39</sup> reported on a retrospective review of 602 patients undergoing general foot and ankle surgery utilizing VTE prophylaxis which varied depending on the treating surgeon. The diagnosis of VTE was made by clinical exam, and a 4% incidence of VTE was reported. A significantly increased risk was present in cases involving postoperative immobilization, previous DVT, rheumatoid arthritis, and recent air travel.

As in hip arthroscopy, screening patients for VTE risk in ankle arthroscopy involves the evaluation of general medical risk factors (Table 2). No specific studies of VTE in isolated arthroscopic ankle cases have been reported, but unique risk factors can be extrapolated from a small number of studies focusing on ankle surgery in general (Table 4). Orthopaedic surgeons should consider some sort of VTE prophylaxis when these risk factors are present, but no guidelines or studies have been reported regarding the choice of prophylaxis.

## KNEE ARTHROSCOPY

The majority of the literature regarding VTE of lower extremity arthroscopy involves the knee. The

**TABLE 4.** *Risk Factors for Venous Thromboembolism Associated Specifically with Foot and Ankle Surgery*

Postoperative immobilization
Nonweightbearing status
Hindfoot surgery
Increasing tourniquet time
Advancing age
Previous thromboembolic event
Rheumatoid arthritis
Recent air travel

two major groups of studies that exist are those determining the incidence of VTE without prophylaxis and those evaluating the prophylactic benefit of low-molecular weight heparin (LMWH). The remaining literature involves case reports and small series illustrating important considerations in medical management. Upon a thorough review of the literature, the incidence of VTE associated with knee arthroscopy ranges from 0% to 17.9% (Table 5).<sup>55-75</sup>

## Incidence

Articles associating VTE and knee arthroscopy include those that have reported both the incidence of DVT and/or PE. Some of these studies published the incidence of thromboembolic events as their

**TABLE 5.** *Reported Incidence of Venous Thromboembolism in Knee Arthroscopy*

Author	Year	DVT	PE
Jackson and Abe <sup>55</sup>	1972	1.4%	0.5%
McGinty et al. <sup>56</sup>	1977	7.3%	0%
Carson <sup>57</sup>	1979	4.9%	1.6%
Guhl <sup>58</sup>	1979	1.0%	0%
Lysholm et al. <sup>59</sup>	1981	1.0%	0%
Dandy and O'Carroll <sup>60</sup>	1982	0.3%	0%
Mulhollan <sup>61</sup>	1982	0.3%	0.02%
DeLee <sup>62</sup>	1985	0.1%	0.03%
Rand <sup>63</sup>	1985	3.4%	0%
Coudane et al. <sup>64</sup>	1986	0.75%	0.25%
Collins <sup>65</sup>	1989	0.3%	0.06%
Stringer et al. <sup>66</sup>	1989	4.2%	0%
Williams et al. <sup>67</sup>	1995	3.5%	0%
Cullison et al. <sup>68</sup>	1996	1.5%	0%
Durica et al. <sup>69</sup>	1997	3.2%	0%
Demers et al. <sup>70</sup>	1998	17.9%	0%
Delis et al. <sup>71</sup>	2001	7.8%	0%
Berqvist and Lowe <sup>72</sup>	2002	4.2%	0%
Ng et al. <sup>73</sup>	2005	1.2%	0%
Hoppener et al. <sup>74</sup>	2006	5.7%	0.003%
Reigstad and Grimsgaard <sup>75</sup>	2006	0%	0.17%

Abbreviations. DVT, deep venous thrombosis; PE, pulmonary embolism.

primary focus, while others reported it secondarily as part of a study with a different goal. The incidence of VTE, DVT, and PE differs significantly among various studies based upon multiple factors, including patient age, medical history, and type of surgical procedure performed. The literature and its reports of incidence reflect the changes in VTE management over the last 3 decades. In the 1980s and 1990s, published studies regarding the incidence of VTE and knee arthroscopy reported the diagnosis based upon clinical signs and symptoms—a method which suffers from low sensitivities and specificities. Recent articles have reported that 40% to 50% of cases of DVT diagnosed by ultrasound or venogram were clinically asymptomatic, implying that the earlier studies may have missed several cases of VTE.<sup>71</sup> In more recently published articles, however, the diagnosis has been based upon the objective results of venography and/or ultrasound.

Perhaps the best overall analysis of VTE incidence after knee arthroscopy in patients without prophylaxis is a meta-analysis by Ilahi et al.<sup>76</sup> which included a review of six studies and a total of 684 patients.<sup>77</sup> This meta-analysis suggested an overall DVT rate of 9.9% and a proximal DVT rate of 2.1%. Criteria for inclusion in the meta-analysis were screening for DVT with ultrasound or venography and the exclusion of concomitant ligament repair or open knee surgical procedures.

Obviously, the general medical risk factors for VTE incidence also apply to knee arthroscopy (Table 2). A direct assessment of some of these factors has been performed in some studies specific to knee arthroscopy. Demers et al.<sup>70</sup> performed an analysis which included age, sex, family history of VTE, previous personal history of VTE, home medications, anesthesia, duration of surgery, duration of immobilization, and tourniquet time. Despite a review of all of these risk factors, only a tourniquet time of greater than 60 minutes was found to be a statistically significant factor associated with the development of VTE. Delis et al.<sup>71</sup> studied the following criteria: age greater than 65 years, body mass index over 30, smoking, hormone replacement or contraceptive use, history of chronic venous insufficiency, and history of previous VTE. In this series, the only statistically significant single risk factor was a history of previous VTE. The authors also concluded that two or more general risk factors for hypercoagulability increased the risk of VTE after knee arthroscopy.<sup>71</sup>

## Prophylaxis

The second major group of articles regarding VTE in knee arthroscopy involves a series of studies regarding prophylactic options. There are three published randomized, controlled trials and three cohort studies that have assessed prophylaxis with LMWH after knee arthroscopy. While results have varied slightly between these studies, the overall consensus seems to be that LMWH is effective at reducing VTE risk.

Wirth et al.<sup>78</sup> followed 239 total patients and randomized them into matched groups: 117 receiving reviparin for 7 to 10 days after surgery and 122 receiving no treatment. DVT was diagnosed by color-coded sonography. There was a VTE incidence of 0.85% in the reviparin group and 4.1% in the control group, correlating with a relative risk reduction of 80%. The single patient with a DVT in the reviparin group was found to have low levels of protein C and protein S, indicating a possible coagulopathy. There were no patients with major bleeding episodes in the reviparin group.<sup>78</sup>

Michot et al.<sup>79</sup> published a similar study involving 130 patients randomized into two groups: 66 treated with dalteparin and 64 without prophylaxis. The first dose of LMWH was given just before surgery and continued daily for 4 weeks. DVT was diagnosed by compression ultrasonography. There was a VTE incidence of 15.6% without prophylaxis and 1.5% with prophylaxis. This represented a statistically significant risk reduction for VTE ( $P = .004$ ). The authors reported that 80% of all DVTs were diagnosed within the first 2 weeks after surgery.<sup>79</sup>

Marlovits et al.<sup>80</sup> reported on 175 patients undergoing arthroscopic anterior cruciate ligament repair. All patients received enoxaparin preoperatively and during their 3- to 8-day postoperative hospitalization. Patients were then randomized into two groups: 87 patients receiving enoxaparin and 88 receiving placebo for 3 weeks after discharge. This study employed magnetic resonance venography to evaluate for DVT and lung scans to evaluate for PE. There was a 2.8% incidence of DVT in patients treated with enoxaparin, compared to a 41.2% incidence of DVT of those receiving placebo. This represented a statistically significant reduction in risk of DVT with enoxaparin ( $P < .001$ ). There was no statistically significant difference in bleeding events between the two groups, and there were no cases of PE. After an analysis of risk factors, this study concluded that age greater than 30



years and immobilization before surgery were statistically significant for increased risk of VTE.

Three other studies focusing on VTE prophylaxis did not involve a randomized, controlled design but still merit discussion here. Schippinger et al.<sup>81</sup> and Obernosterer et al.<sup>82</sup> followed a cohort of 101 patients who received dalteparin after knee arthroscopy. Ultrasound, phlebography, and lung scans were used to screen for DVT and PE. This study reported a 12% rate of VTE. Three patients had DVT, 4 patients developed PE, and 5 patients had both DVT and PE. This study reported an increased rate of VTE in spite of LMWH prophylaxis, which is especially concerning in that 4 of the 8 DVTs and 8 of the 9 PEs were clinically silent. There was no correlation with tourniquet time, anesthetic type, or duration of surgery with the incidence of DVT.

Holland and Schain<sup>83</sup> reviewed 102 patients who underwent postoperative prophylactic treatment with nadroparin for 5 to 6 days after knee arthroscopy. There was a 4.9% rate of symptomatic DVT in spite of prophylaxis with LMWH. Eighty percent of the DVTs occurred after prophylactic treatment was terminated.

Montebugnoli et al.<sup>84</sup> reported no proximal DVT or other thromboembolic events in a study of 509 patients receiving parnaparin after minor arthroscopic knee surgery. The authors recommended treatment with the LMWH for 10 days after surgery. There were 8 adverse events related to the parnaparin, however, raising some concern about the risk–benefit ratio of treatment.<sup>84</sup>

Future research is required to determine if the benefits of prophylaxis for VTE after knee arthroscopy outweigh the risks and costs. However, the randomized, controlled trials of LMWH prophylaxis seem to support its use in decreasing the risk of VTE after knee arthroscopy. Yet the cohort studies illustrate that multiple issues must be resolved before definitive prophylactic treatment recommendations can be made. A recent Cochrane Database review<sup>7</sup> highlighted the inability of the current literature to definitively support thromboprophylaxis of any type, and recommended that future studies perform more organized stratification of patients by risk factor and type of procedure. The type of LMWH, duration of therapy, timing of therapy (preoperative and postoperative), method of DVT/PE diagnosis, and screening for other risk factors may all play a role in the analysis of LMWH efficacy and also must be considered. Although future studies will be required to determine the appropriate methodology of using LMWH, this treatment currently represents the best literature-supported

option for prophylaxis.<sup>4,78-81,83</sup> Specific indications for LMWH use thus remain to be more clearly defined. In addition, while the use of other methods such as aspirin, warfarin, heparin, and multimodal prophylaxis have all been well described in relation to total joint arthroplasty, no studies have focused on their use specifically for arthroscopy.

### Fatal Pulmonary Embolism

As evidenced by the literature discussed earlier, PE appears to be a very rare occurrence in association with knee arthroscopy, and most cases of PE are clinically silent or respond to treatment.<sup>85-88</sup> Several case reports of fatal PE exist in which one or more risk factors were present for VTE.<sup>89-92</sup> In some cases, however, the only risk factor may have been the arthroscopy itself (i.e., lower extremity surgery as a risk factor). For example, a fatal PE was reported by Navarro-Sanz and Fernandez-Ortega<sup>91</sup> in a 46-year-old man who had no known risk factors other than his orthopaedic procedure, which involved a tourniquet time of only 35 minutes. This case serves as a reminder of the importance of always considering the potential risk of VTE in every surgical case, appropriately discussing the possibility of this complication with the patient preoperatively, and documenting that discussion in the medical record.

Another recent case report by Janssen and Sala<sup>92</sup> involved a 17-year-old female soccer player who suffered a fatal PE after an anterior cruciate ligament reconstruction. This patient had identifiable risk factors of oral contraceptive use and family history of coagulopathy. This case raises the question of whether or not to discontinue oral contraceptives before and after knee arthroscopy. Berg and Montanarella<sup>93</sup> recommended that oral contraceptive pills be continued with the addition of chemoprophylaxis in patients undergoing knee arthroscopy—arguing that the risk of pregnancy-related death as a consequence of unprotected sex is higher than the risk of death as a complication of oral contraceptive use.

### CONCLUSIONS

VTE remains one of the most feared potential complications of arthroscopy of the lower extremity. There have been no reports of cases of DVT or PE associated with hip or ankle arthroscopy to date, and thus the surgeon should base prophylaxis decisions before these procedures on the existing medical factors associated with each individual patient. The vast

majority of existing data about VTE prophylaxis in lower extremity arthroscopy pertains to the knee, including specific guidelines and recommendations. The incidence of VTE associated with knee arthroscopy appears to be approximately 10% and can be reduced with the use of prophylactic LMWH. Presently, however, the guidelines of the Seventh ACCP Conference on Antithrombotic and Thrombolytic Therapy remain the only current official recommendations that are specific to knee arthroscopy. The guidelines recommend prophylaxis with LMWH only when patients have pre-existing risk factors for hypercoagulability or after a complicated/prolonged procedure.<sup>4</sup> Further research is required to evaluate thromboembolic disease in lower extremity arthroscopy, with attention to specifics such as indications, risks, benefits, dosages, intervals, costs, and other features of various prophylactic options.

## REFERENCES

- Sherman OH, Fox JM, Snyder SJ, et al. Arthroscopy—"No-problem surgery." An analysis of complications in two thousand six hundred and forty cases. *J Bone Joint Surg Am* 1986;68:256-265.
- Berry DJ. Venous thromboembolism after a total hip arthroplasty: Prevention and treatment. *Instr Course Lect* 2003;52:275-280.
- Agudelo JF, Morgan SJ, Smith WR. Venous thromboembolism in orthopedic trauma patients. *Orthopedics* 2005;28:1164-1173.
- Geerts WH, Pineo GF, Heit JA, et al. Prevention of venous thromboembolism: The Seventh ACCP Conference on Antithrombotic and Thrombolytic Therapy. *Chest* 2004;126:338S-400S.
- Callaghan JJ, Dorr LD, Engh GA, et al. Prophylaxis for thromboembolic disease: Recommendations from the American College of Chest Physicians—Are they appropriate for orthopaedic surgery? *J Arthroplasty* 2005;20:273-274.
- Colwell CW, Lassen MR, Bergqvist D, et al. Prophylaxis for the thromboembolic disease: Recommendations from the American College of Chest Physicians—Are they appropriate for orthopaedic surgery? *J Arthroplasty* 2006;21:148-149.
- Ramos J, Perrotta C, Badarotti G, Berenstein G. Interventions for preventing venous thromboembolism in adults undergoing knee arthroscopy. *Cochrane Database Syst Rev* 2007;2:CD005259.
- Johanson NAC. *American Academy of Orthopaedic Surgeons clinical guideline on prevention of symptomatic pulmonary embolism in patients undergoing total hip or knee arthroplasty*. Available online at [http://www.aaos.org/Research/guidelines/PE\\_guideline.pdf](http://www.aaos.org/Research/guidelines/PE_guideline.pdf).
- Hawkins RB. Arthroscopy of the hip. *Clin Orthop Relat Res* 1989;249:44-47.
- Glick JM, Sampson TG, Gordon RB, Behr JT, Schmidt E. Hip arthroscopy by the lateral approach. *Arthroscopy* 1987;3:4-12.
- Small NC. Complications in arthroscopic surgery performed by experienced arthroscopists. *Arthroscopy* 1988;4:215-221.
- Funke EL, Munzinger U. Complications in hip arthroscopy. *Arthroscopy* 1996;12:156-159.
- Byrd JWT, Chern KY. Traction versus distension for distraction of the joint during hip arthroscopy. *Arthroscopy* 1997;13:346-349.
- Baber YF, Robinson AHN, Villar RN. Is diagnostic arthroscopy of the hip worthwhile? A prospective review of 328 adults investigated for hip pain. *J Bone Joint Surg Br* 1999;81:600-603.
- Griffin DR, Villar RN. Complications of arthroscopy of the hip. *J Bone Joint Surg Br* 1999;81:604-606.
- Byrd JWT, Jones KS. Prospective analysis of hip arthroscopy with 2-year follow-up. *Arthroscopy* 2000;16:578-587.
- McCarthy JC, Noble PC, Schuck MR, Wright J, Lee J. The Otto E. Aufranc Award: The role of labral lesions to development of early degenerative hip disease. *Clin Orthop Relat Res* 2001;393:25-37.
- Dienst M, Godde S, Seil R, Hammer D, Kohn D. Hip arthroscopy without traction: in vivo anatomy of the peripheral hip joint cavity. *Arthroscopy* 2001;17:924-931.
- O'Leary JA, Berend K, Vail TP. The relationship between diagnosis and outcome in arthroscopy of the hip. *Arthroscopy* 2001;17:181-188.
- Sampson TG. Complications of hip arthroscopy. *Clin Sports Med* 2001;20:831-835.
- Byrd JWT. Hip arthroscopy: The supine position. *Instr Course Lect* 2003;52:721-730.
- Clarke MT, Arora A, Villar RN. Hip arthroscopy: Complications in 1054 cases. *Clin Orthop Relat Res* 2003;406:84-88.
- Keeney JA, Peele MW, Jackson J, Rubin D, Maloney WJ, Clohisy JC. Magnetic resonance arthrography versus arthroscopy in the evaluation of articular hip pathology. *Clin Orthop Relat Res* 2004;429:163-169.
- McCarthy JC. Hip arthroscopy: When it is and when it is not indicated. *Instr Course Lect* 2004;53:615-621.
- Pasa L, Hart R, Kocis J, Muzik V, Vesely R. Arthroscopy of the hip joint. *Acta Chir Orthop Traumatol Cech* 2005;72:16-21.
- Yamamoto Y, Ide T, Nakamura M, Hamada Y, Usui I. Arthroscopic partial limbectomy in hip joints with acetabular hypoplasia. *Arthroscopy* 2005;21:586-591.
- Yamamoto Y, Hamada Y, Ide T, Usui I. Arthroscopic surgery to treat intra-articular type snapping hip. *Arthroscopy* 2005;21:1120-1125.
- Awan N, Murray P. Role of hip arthroscopy in the diagnosis and treatment of hip joint pathology. *Arthroscopy* 2006;22:215-218.
- Lo YP, Chan YS, Lien LC, Lee MS, Hsu KY, Shih CH. Complications of hip arthroscopy: Analysis of seventy-three cases. *Chang Gung Med J* 2006;29:86-92.
- Jerosh J, Schunck J, Khoja A. Arthroscopic treatment of the hip in early and midstage degenerative joint disease. *Knee Surg Sports Traumatol Arthrosc* 2006;14:641-645.
- Mullis BH, Dahners LE. Hip arthroscopy to remove loose bodies after traumatic dislocation. *J Orthop Trauma* 2006;20:22-26.
- Owens BD, Busconi BD. Arthroscopy for hip dislocation and fracture-dislocation. *Am J Orthop* 2006;35:584-587.
- Bushnell BD, Hoover SA, Olcott CW, Dahners LE. Use of an independent skeletal distractor in hip arthroscopy. *Arthroscopy* 2007;23:106.e101-106.e104.
- Kim KC, Hwang DS, Lee CH, Kwon ST. Influence of femoroacetabular impingement on results of hip arthroscopy in patients with early osteoarthritis. *Clin Orthop Relat Res* 2007;456:128-132.
- Philippon MJ, Schenker ML, Briggs KK, Kuppessmith DA. Femoroacetabular impingement in 45 professional athletes: Associated pathologies and return to sport following arthroscopic decompression. *Knee Surg Sports Traumatol Arthrosc* 2007;15:908-914.
- Philippon MJ, Schenker ML, Briggs KK, Kuppessmith DA,

- Maxwell RB, Stubbs AJ. Revision hip arthroscopy. *Am J Sports Med* 2007;35:1918-1921.
37. Mizel MS, Temple HT, Michelson JD, et al. Thromboembolism after foot and ankle surgery: A multicenter study. *Clin Orthop Relat Res* 1998;348:180-185.
  38. Solis G, Saxby T. Incidence of DVT following surgery of the foot and ankle. *Foot Ankle Int* 2002;23:411-414.
  39. Hanslow SS, Grujic L, Slater HK, Chen D. Thromboembolic disease after foot and ankle surgery. *Foot Ankle Int* 2006;27:693-695.
  40. van Dijk CN, Bossuyt PM, Marti RK. Medial ankle pain after lateral ligament rupture. *J Bone Joint Surg Br* 1996;78:562-567.
  41. Harrington P, Aiyaswami KV, Stephens MM. Diagnostic and therapeutic ankle arthroscopy. *Ir J Med Sci* 1996;165:121-124.
  42. Acevedo JI, Busch MT, Ganey TM, Hutton WC, Ogden JA. Coaxial portals for posterior ankle arthroscopy: An anatomic study with clinical correlation on 29 patients. *Arthroscopy* 2000;16:836-842.
  43. Rasmussen S, Hjorth Jensen C. Arthroscopic treatment of impingement of the ankle reduces pain and enhances function. *Scand J Med Sci Sports* 2002;12:69-72.
  44. Ono A, Nishikawa S, Nagao A, Irie T, Sasaki M, Kouno T. Arthroscopically assisted treatment of ankle fractures: Arthroscopic findings and surgical outcomes. *Arthroscopy* 2004;20:627-631.
  45. Hintermann B, Valderrabano V, Boss A, Trouillier HH, Dick W. Medial ankle instability: An exploratory, prospective study of fifty-two cases. *Am J Sports Med* 2004;32:183-190.
  46. Thomas B, Yeo JM, Slater GL. Chronic pain after ankle fracture: an arthroscopic assessment case series. *Foot Ankle Int* 2005;26:1012-1016.
  47. Nihal A, Rose DJ, Trepman E. Arthroscopic treatment of anterior ankle impingement syndrome in dancers. *Foot Ankle Int* 2005;26:908-912.
  48. Maiotti M, Massoni C, Tarantino U. The use of arthroscopic thermal shrinkage to treat chronic lateral ankle instability in young athletes. *Arthroscopy* 2005;21:751-757.
  49. Ferkel RD, Hewitt M. Long-term results of arthroscopic ankle arthrodesis. *Foot Ankle Int* 2005;26:275-280.
  50. Okuda R, Kinoshita M, Morikawa J, Yasuda T, Abe M. Arthroscopic findings in chronic lateral ankle instability: Do focal chondral lesions influence the results of ligament reconstruction? *Am J Sports Med* 2005;33:35-42.
  51. Lui TH, Chan WK, Chan KB. The arthroscopic management of frozen ankle. *Arthroscopy* 2006;22:283-286.
  52. Savva N, Jabur M, Davies M, Saxby T. Osteochondral lesions of the talus: Results of repeat arthroscopic debridement. *Foot Ankle Int* 2007;28:669-673.
  53. Collman DR, Kaas MH, Schuberth JM. Arthroscopic ankle arthrodesis: Factors influencing union in 39 consecutive patients. *Foot Ankle Int* 2006;27:1079-1085.
  54. Hassan AH. Treatment of anterolateral impingements of the ankle joint by arthroscopy. *Knee Surg Sports Traumatol Arthrosc* 2007;15:1150-1154.
  55. Jackson RW, Abe I. The role of arthroscopy in the management of disorders of the knee. An analysis of 200 consecutive examinations. *J Bone Joint Surg Br* 1972;54:310-322.
  56. McGinty JB, Geuss LF, Marvin RA. Partial or total meniscectomy: A comparative analysis. *J Bone Joint Surg Am* 1977;59:763-766.
  57. Carson RW. Arthroscopic meniscectomy. *Orthop Clin North Am* 1979;10:619-627.
  58. Guhl JF. Operative arthroscopy. *Am J Sports Med* 1979;7:328-335.
  59. Lysholm J, Gillquist J, Liljedahl SO. Arthroscopy in the early diagnosis of injuries to the knee joint. *Acta Orthop Scand* 1981;52:111-118.
  60. Dandy DJ, O'Carroll PF. Arthroscopic surgery of the knee. *Br Med J (Clin Res Ed)* 1982;285:1256-1258.
  61. Mulholland JS. Symposium: Arthroscopic knee surgery. *Contemp Orthop* 1982;5:79-112.
  62. DeLee JC. Complications of arthroscopy and arthroscopic surgery: Results of a national survey. *Arthroscopy* 1985;1:214-220.
  63. Rand JA. Arthroscopic management of degenerative meniscus tears in patients with degenerative arthritis. *Arthroscopy* 1985;1:253-258.
  64. Coudane H, Mole D, Sommelet J, de Ren G, Schmitt D. Complications of arthroscopies. *J Med Légale* 1986;29:147-151.
  65. Collins JJ. Knee-joint arthroscopy—Early complications. *Med J Aust* 1989;150:702-706.
  66. Stringer MD, Steadman CA, Hedges AR, Thomas EM, Morley TR, Kakkar VV. Deep vein thrombosis after elective knee surgery. An incidence study in 312 patients. *J Bone Joint Surg Br* 1989;71:492-497.
  67. Williams JS, Hulstyn MJ, Fadale PD, et al. Incidence of deep vein thrombosis after arthroscopic knee surgery: A prospective study. *Arthroscopy* 1995;11:701-705.
  68. Cullison TR, Muldoon MP, Gorman JD, Goff WB. The incidence of deep venous thrombosis in anterior cruciate ligament reconstruction. *Arthroscopy* 1996;12:657-659.
  69. Durica S, Raskob G, Johnson C, et al. Incidence of deep-vein thrombosis after arthroscopic knee surgery. *Thromb Haemost* 1997;79:183.
  70. Demers C, Marcoux S, Ginsberg JS, Laroche F, Cloutier R, Poulin J. Incidence of venographically proved deep vein thrombosis after knee arthroscopy. *Arch Intern Med* 1998;158:47-50.
  71. Delis KT, Hunt N, Strachan RK, Nicolaides AN. Incidence, natural history, and risk factors of deep vein thrombosis in elective knee arthroscopy. *Thromb Haemost* 2001;86:817-821.
  72. Bergqvist D, Lowe G. Venous thromboembolism in patients undergoing laparoscopic and arthroscopic surgery and in leg casts. *Arch Intern Med* 2002;162:2173-2176.
  73. Ng WM, Chan KY, Lim AB, Gan EC. The incidence of deep venous thrombosis following arthroscopic knee surgery. *Med J Malaysia* 2005;60:14-16.
  74. Hoppener MR, Ettema HB, Henny CP, Verheyen CC, Buller HR. Low incidence of deep vein thrombosis after knee arthroscopy without thromboprophylaxis: A prospective cohort study of 335 patients. *Acta Orthop* 2006;77:767-771.
  75. Reigstad O, Grimsaard C. Complications in knee arthroscopy. *Knee Surg Sports Traumatol Arthrosc* 2006;14:473-477.
  76. Ilahi OA, Reddy J, Ahmad I. Deep venous thrombosis after knee arthroscopy: A meta-analysis. *Arthroscopy* 2005;21:727-730.
  77. Streubel PN. Deep venous thrombosis after knee arthroscopy: A meta-analysis. *Arthroscopy* 2005;21:1408-1410.
  78. Wirth T, Schneider B, Misselwitz F, et al. Prevention of venous thromboembolism after knee arthroscopy with low-molecular weight heparin (Reviparin): Results of a randomized controlled trial. *Arthroscopy* 2001;17:393-399.
  79. Michot M, Conen D, Holtz D, et al. Prevention of deep-vein thrombosis in ambulatory arthroscopic knee surgery: A randomized trial of prophylaxis with low-molecular weight heparin. *Arthroscopy* 2002;18:257-263.
  80. Marlovits S, Striessnig G, Schuster R, et al. Extended-duration thromboprophylaxis with enoxaparin after arthroscopic surgery of the anterior cruciate ligament: A prospective, randomized, placebo-controlled study. *Arthroscopy* 2007;23:696-702.
  81. Schippinger G, Wirnsberger GH, Obernosterer A, Babinski K. Thromboembolic complications after arthroscopic knee surgery. Incidence and risk factors in 101 patients. *Acta Orthop Scand* 1998;69:144-146.
  82. Obernosterer A, Schippinger G, Lipp RW, Wirnsberger G,

- Roller R, Pilger E. Thromboembolic events following arthroscopic knee surgery. *JAMA* 1999;281:431.
83. Holland K, Schain FH. Prevention of thrombosis with fraxiparin 0.3 after arthroscopic interventions. *Fortschr Med* 1995;113:335-336.
84. Montebugnoli M, Bugamelli S, Cala P, Zangheri E, Ferrari P. Prophylaxis of venous thromboembolism in minor orthopedic surgery with parnaparin. *Clin Appl Thromb Hemost* 2007;13:249-258.
85. Bartosh RA, Gibson WK, Staeheli JW. Pulmonary embolism as a complication of arthroscopic surgery. *Orthop Rev* 1989;18:1173-1175.
86. Poulsen KA, Borris LC, Lassen MR. Thromboembolic complications after arthroscopy of the knee. *Arthroscopy* 1993;9:570-573.
87. Seon JK, Song EK, Yoon TR, Park SJ, Seo HY. An unusual case of pulmonary embolism after arthroscopic meniscectomy. *Arch Orthop Trauma Surg* 2006;126:641-643.
88. Pola E, Flex A, Papaleo P, Gaetani E, Delcogliano A, Pola P. Deep venous thrombosis and pulmonary embolism after knee arthroscopy in athletes carrying the thrombophilic factor lupus anticoagulant. *Arthroscopy* 2005;21:103-107.
89. Rozencwaig R, Shilt JS, Ochsner JL. Fatal pulmonary embolus after knee arthroscopy. *Arthroscopy* 1996;12:240-241.
90. Enyon AM, James S, Leach P. Thromboembolic events after arthroscopic knee surgery. *Arthroscopy* 2004;20:23-24.
91. Navarro-Sanz A, Fernandez-Ortega JF. Fatal pulmonary embolism after knee arthroscopy. *Am J Sports Med* 2004;32:525-528.
92. Janssen RP, Sala HA. Fatal pulmonary embolism after anterior cruciate ligament reconstruction. *Am J Sports Med* 2007;35:1000-1002.
93. Fleiss DJ. A fatal pulmonary embolus after arthroscopy in a morbidly obese woman. *Arthroscopy* 1999;15:231-232.