Current Evidence on Uterine Embolization for Fibroids

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Abstract

Keywords

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- comparative effectiveness

Strong evidence for both safety and effectiveness of uterine fibroid embolization has been generated since the procedure's introduction. This review will focus on the key articles representing the best evidence to summarize the outcomes from uterine embolization. This review will attempt to answer three important questions associated with uterine embolization. First, does uterine embolization relieve symptoms caused by uterine fibroids? Second, how well does the improvement in symptoms and quality of life after uterine embolization compare with standard surgical options for fibroids? Finally, how durable is the improvement in fibroid-related symptoms and quality of life after embolization?

Objectives: Upon completion of this article, the reader will be able to discuss the currently available evidence supporting the use of uterine artery embolization in the treatment of fibroids.

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In little over a decade, uterine fibroid embolization (UFE) has become well established in the management of uterine fibroids. It represents a fundamentally new approach to fibroids, one based on using ischemic infarction to destroy the fibroids. Until the introduction of UFE, essentially all gynecologic approaches were centered either on hormonal treatment to control symptoms or surgery to remove the uterus or the fibroids.

Strong evidence for both safety and effectiveness of UFE has been generated since the procedure's introduction.^{1,2}

A search of PubMed using the search terms “uterine embolization” and “leiomyoma” yields more than 900 references. There have been innumerable studies of symptom improvement, change in quality of life, comparative outcomes, procedure technique, embolic material, fertility after embolization, and other aspects of the procedure. The evidence is now so broad that it is difficult to summarize in one short article.

Given the limitations of space, this review will focus on the key articles representing the best evidence to summarize the outcomes from uterine embolization. This approach provides a more succinct and directed review, one more easily understood and remembered. The author will attempt to answer three important questions associated with uterine embolization. First, does uterine embolization relieve symptoms caused by uterine fibroids? Second, how well does the improvement in symptoms and quality of life after uterine embolization compare with standard surgical options for fibroids? Finally, how durable is the improvement in fibroid-related symptoms and quality of life after embolization?

Background

Uterine fibroids or leiomyomas are benign muscular and fibroid tumors of the uterus. They are very common, with a cumulative incidence of well over 50% by age 50.³ Although a minority of women with fibroids will develop symptoms

requiring treatment, the very high incidence of the condition results in a large number of patients requiring therapy to manage symptoms.

The symptoms from uterine fibroids have often been divided into three groups: heavy menstrual bleeding, pelvic pain, and bulk symptoms (pressure, bloating, and urinary symptoms caused by the size and position of the fibroids). The most common symptom of patients presenting for evaluation is heavy menstrual bleeding. In one large cohort of patients, heavy menstrual bleeding was present in 84.5% of patients and was the dominant symptom in 65%.⁴ In that same study, pelvic pain was the primary symptom in 10.5%, though 62% had some pain. Bulk-related symptoms were present in 83.9% and were the primary symptom in 23.3%.

Symptom Control after Uterine Fibroid Embolization

The earliest studies investigating this question were small case series, each showing initially positive outcomes.^{1,2,5-7} None of these studies was large, but each suggested that both heavy menstrual bleeding, pain, pressure, discomfort, and other symptoms related to the bulk of the fibroids responded to embolization, with subsequent shrinkage of the fibroids and relief of symptoms in most patients.

One of the early, large series was published by Hutchins et al.⁶ Three hundred five patients were treated, with follow-up up to 12 months posttreatment. Menorrhagia was controlled in 86% of patients at 3 months and 92% at 12 months; bulk symptoms were controlled in 64% of patients at 3 months and 92% at 12 months.

Pelage subsequently reported on the results of 80 consecutive patients treated for menorrhagia caused by fibroids.⁸ This group of patients had a minimum of 2 years follow-up. Menorrhagia was controlled in 90% of patients. Hysterectomy was required in one patient for infection, while portions of fibroids were expelled in four patients in the first month postprocedure. Four patients experienced permanent amenorrhea after the procedure.

Several other early studies showed similar results. Bruner-eau et al, from Paris, published the results on 58 patients with a mean duration of follow-up of 12 months.⁹ As in the other series, a high percentage of patients had improved bleeding (90% at 3 months). McLucas et al from Los Angeles reported on the outcomes in 167 patients with a mean of 6 months follow-up, with menorrhagia improved in 82% of patients.¹⁰

Goodwin et al reported mid-term results on their initial group of 60 patients.⁵ With a mean of 16.3 months follow-up, 81% had continued control of symptoms. Seven patients had undergone hysterectomy in the follow-up period.

Spies et al reported on results, including subsequent gynecologic interventions, in 200 consecutive patients.¹¹ This patient group had a mean follow-up of 21 months. Menorrhagia was improved in 87% and bulk symptoms were improved in 93% at 3 months. At 1 year, 90% of patients still had symptom control. During the course of follow-up, subsequent gynecologic interventions or rehospitalizations

occurred in 21 patients (10.5%). Of these, approximately half was for failure to improve or recurrence of fibroids.

Several larger trials followed. Walker and Pelage summarized their results in 400 patients.¹² This study confirmed the earlier studies. With an average of 16.7 months follow-up, menstrual bleeding was improved in 84% and menstrual pain improved in 79%. Twenty-six women (6%) had clinical failure. In an even larger group of patients ($n = 550$), Pron et al reported initial results from the Ontario Uterine Fibroid Embolization Trial.^{13,14} Very similar results to those reported earlier were noted, with menorrhagia improved in 83%, dysmenorrhea improved in 77%, and urinary frequency improved in 86%.¹⁵

Although all these trials showed promising results, they reflected the results in expert centers. In order for the procedure to gain wide acceptance, the outcomes are needed from patients in the community across a wide range of practice settings. The FIBROID Registry was created to collect those outcomes.

The FIBROID Registry

In 1999, the Society of Interventional Radiology (SIR) Foundation, in conjunction with Duke Clinical Research Institute, developed the Fibroid Registry for Outcomes Data (FIBROID Registry).⁴ This multicenter registry, funded by several industry partners, had 72 enrolling sites, representing a wide range of both academic and private practice settings. The goal was the collection of prospective data on a large number of UFE patients, to assess short- and long-term outcomes by measuring symptom severity, change in symptoms, adverse events, and health-related quality of life for 3 years after therapy. A self-administered validated questionnaire, the Uterine Fibroid Symptom and Quality of Life (UFS-QOL) questionnaire, measures symptom status and health-related quality of life,¹⁶ and its symptom scale was the primary outcome measure of the registry. The symptom score ranges from 0 to 100, with lower scores indicating less severe symptoms. A recent study of symptom status of women undergoing treatment for uterine fibroids compared with those without fibroids found a mean symptom score for a normal patient was 15.3 with a standard deviation of 14.5.¹⁷

The first report of clinical outcomes from the registry presented outcomes at 6 and 12 months.¹⁸ Baseline scores of 2,666 uterine fibroid patients were reported with a mean symptom score from the UFS-QOL of 59.83 (standard deviation [SD] 20.8), indicating that the FIBROID Registry patients were generally quite symptomatic. At 6 months after UFE, the mean symptom score improved to 19.87 (SD 18.6), which remained stable at 12 months (19.23; SD 17.9). Thus, patients on average went from very symptomatic to near-normal level of symptoms as a result of embolization. Subsequently, the long-term results from the FIBROID Registry patients were published and revealed mean UFS-QOL symptom scores of 18.3 at 2 years and 16.5 at 3 years.¹⁹ This large cohort study confirmed that in the vast majority of patients, the symptoms associated with uterine fibroids are controlled by embolization.

Nonrandomized Comparative Studies

Although it appeared that most patients had symptomatic improvement after embolization, the extent of that improvement was difficult to assess without some comparator procedure. Although the case series outlined above provided useful data, the outcomes were in a self-selected group of patients who were perhaps motivated to avoid surgery. Therefore, comparative data were needed. The first issue that investigators faced was which treatment should be the standard by which to compare.

Hysterectomy has been the primary therapy for symptomatic fibroids for decades and is by far the most common intervention for fibroids. Having said that, the most important uterine-sparing therapy for fibroids has been myomectomy, typically performed in women wishing to preserve fertility. For this reason, many of the UFE comparative studies have used either hysterectomy or myomectomy as the control therapy. There are newer interventions, most notably laparoscopic uterine artery ligation and magnetic resonance-guided focused ultrasound surgery (MRgFUS). The former has been compared with UFE in several small, randomized trials, but given the limited data currently available, will not be included in this review. To date, there have not been any published studies directly comparing the outcomes from MRgFUS to other fibroid therapies, and therefore will also not be discussed further here.

There have been many comparative studies of UFE outcomes, although until recently the majority of these were not randomized. Although a randomized study design is likely to result in less selection bias and has the benefit of random allocation of patient-specific factors that might confound analysis, there are a few important nonrandomized trials that bear consideration.

One of the earliest myomectomy comparative studies was a retrospective review of a series of patients treated with UFE or myomectomy at a single medical center by Broder et al.²⁰ These authors compared 51 embolization patients and 30 myomectomy patients who had undergone treatment between 3 and 5 years before the review. They noted similar symptomatic improvement between the two groups, although the re-intervention rate of 29% was higher for the UFE group (compared with 3% for the myomectomy group). A larger, prospective, nonrandomized multicenter trial was published in 2006 by Siskin et al,²¹ and noted that a higher proportion of UFE patients had significant reduction in symptoms compared with myomectomy (88 vs. 75%) and also noted a higher adverse event rate for myomectomy compared with UFE (42 vs. 26%, $p < 0.05$). Spies et al published comparative outcomes from hysterectomy, myomectomy, and UFE compared with normal controls in 2010.¹⁷ In this study, 107 embolization, 61 myomectomy, and 106 hysterectomy patients were studied, and their symptoms and quality of life before and after therapy were compared with a group of 101 normal controls, using the UFS-QOL fibroid questionnaire. Among the fibroid treatment group, the mean symptom score before therapy was 64.8, while normal controls had a mean score of 15.3. Six months after

treatment, with the normal controls unchanged, the mean score for UFE patients was 24.9 and for myomectomy patients 23.4, which was not statistically different. Similar results were noted for quality of life measures. This suggests a similar level of symptom control for myomectomy and UFE. Re-interventions were not reviewed in this study.

There have also been several nonrandomized trials comparing outcomes of UFE and hysterectomy. In an FDA IDE study examining the effectiveness of tris-acryl gelatin microspheres, 102 UFE and 50 hysterectomy patients were treated and outcomes compared.²² Although patients treated with hysterectomy had an advantage at 12 months for relief of pain ($p = 0.012$), for other symptoms there were no differences. Complications were more likely after hysterectomy (50 vs. 27.5%, $p = 0.01$). At 3 years posttreatment, among patients not lost to follow-up, 8% UFE patients had additional intervention and 88% had continued symptom control. If one examines the study cited in the paragraph above,¹⁷ hysterectomy patients clearly had an advantage in terms of symptom control 12 months after therapy, with the mean hysterectomy symptom score of 7.6 compared with 24.9 for UFE and 23.4 for myomectomy. Hysterectomy patients also had significantly fewer symptoms than normal controls (7.6 for hysterectomy vs. 15.3 for normal), reflecting the dependence of this questionnaire's symptom assessment on normal menstrual bleeding. Without any normal menstrual bleeding, hysterectomy patients have artificially depressed symptom scores. As will also be seen with the review of randomized trials that follows, re-intervention is also less likely in hysterectomy patients, as new fibroids cannot develop.

Randomized Trials

A current search of PubMed using the search string "Uterine embolization AND fibroids AND randomized" yields 92 studies. A review of abstracts reveals 26 of these articles are from randomized clinical trials comparing outcomes from uterine embolization to other therapies. Twenty-one of these publications present the results from 7 primary studies comparing UFE to standard surgical therapies, 11 publications from the EMbolization versus hysterectoMY (EMMY) trial alone. The others are divided among four studies comparing embolization to laparoscopic occlusion of the uterine arteries.

Pinto et al published the first randomized trial comparing UFE to surgery and focused on short-term outcomes only.²³ The study found fewer complications and shorter hospital stay after embolization, with symptom control in 86% of UFE patients.

There have been five further major randomized trials that have compared outcomes from embolization with conventional surgery, primarily hysterectomy. The EMMY trial was the first large multicenter randomized trial comparing uterine embolization and hysterectomy. It was completed in The Netherlands and, as noted above, there have been 11 publications presenting various results of this study. Those concentrating on the short- and mid-term outcomes to 2 years are summarized here.^{24–26} In reporting the procedural results, the authors noted a high procedural failure rate of 18%,

which may be related to the relative inexperience of some of the operators. Recovery and return-to-work time was significantly faster after UFE, and there was no difference in the major complication rates. When comparing outcomes, symptom control after embolization and hysterectomy was of a similar magnitude, measured both by patient satisfaction and improvements in quality of life. Although both groups had similar proportions of patients who were at least moderately satisfied with the outcome (UFE 92% vs. hysterectomy 90%), hysterectomy patients had a greater degree of satisfaction with outcome ($p = 0.02$); over the course of the 2-year follow-up, 24% of the embolization patients had recurrence of symptoms that led to hysterectomy. The longer term outcomes from this study are summarized in the next section.

The Randomized Trial of Embolization versus Surgical Treatment for Fibroids (REST) trial was a multicenter study from the United Kingdom that randomized patients to either surgery (hysterectomy or myomectomy) or embolization, and to date there have been four publications from this study.^{27–30} The large majority of the surgical patients in this trial were treated with hysterectomy, with 8 of 51 patients treated with myomectomy. The trial was randomized 2:1 (UFE:surgery). The initial report found UFE patients recovered more quickly and had less pain than surgery patients. At 1 year, both groups had similar degrees of improvement in health-related quality of life and had similar levels of satisfaction. With a median follow-up of 32 months, the likelihood of re-intervention was much higher in UFE patients (21 for UFE vs. 1 for surgery, $p < 0.001$). Ten of these interventions occurred in the first year, presumably due to failure of symptom control and 11 during subsequent follow-up.

Ruuskanen et al published a smaller randomized study in 2010 comparing UFE to hysterectomy,³¹ with 30 patients treated with surgery and 27 with UFE. This study also found that recovery was faster after UFE, both in terms of length of stay and return to work. There were more serious complications with surgery. The hysterectomy patients had significantly better outcomes for control of menorrhagia, but pressure symptoms were improved in a greater proportion of UFE patients; hysterectomy patients were more prone to urinary stress incontinence postprocedure. Additional interventions were performed in 19% of UFE patients during the 2-year follow-up interval, while none were recorded in the hysterectomy group.

There are three randomized trials comparing myomectomy to UFE; one completed by Mara et al,^{32,33} the Fibroids of the Uterus: Myomectomy versus Embolization (FUME) trial in the United Kingdom,³⁴ and the most recent by Jun et al in China.³⁵ In the study by Mara's group, 121 women with a mean age of 32 and an interest in future fertility were randomly assigned to uterine embolization or myomectomy. The primary focus of the first report was on procedural outcomes and confirmed that recovery was shorter and with a shorter hospital stay than myomectomy. There was no difference in overall complication rates and symptom control was similar, with no statistical difference. The second report from Mara et al was focused on reproductive outcomes, which will not be reviewed here. The FUME trial

randomized 163 women to either myomectomy or uterine embolization and focused on symptom and quality of life outcomes.³⁴ For both treatments, at 1 year there were substantial and equal improvements in quality of life scores, although final mean scores in symptoms and some domains of quality of life favored myomectomy. Finally, the study by Jun et al randomized 127 women to either surgery or uterine embolization. Of the 64 undergoing surgery, the large majority (54; 84.4%) underwent myomectomy, with only 10 having hysterectomy. The embolization patients experienced less pain postoperatively, had shorter hospital stays, and shorter overall recoveries. These authors also reported better quality of life status in follow-up in the UFE group, and at 12 months posttreatment, a greater proportion of the population in the UAE group would recommend this treatment to a friend (82 vs. 66%).

There have been two systematic reviews of the outcomes of uterine embolization compared with its surgical alternatives. The first was by van der Kooij et al published in 2011,³⁶ and combined the data from four randomized trials. They concluded that uterine embolization resulted in less blood loss, shorter hospital stay, and faster return to work compared with surgery, with similar levels of improvement in quality of life, but with a higher re-intervention rate than surgery. A more recent Cochrane Review by Gupta et al has recently been published³⁷ and included six randomized trials, yet reached similar results, that is, that uterine embolization has similar short- and mid-term outcomes in terms of symptom control, quality of life, and patient satisfaction. Although it appears to have a higher minor complication rate and more frequent subsequent interventions than surgery, it is also less invasive and therefore has a more rapid recovery and lower procedural costs.

Long-Term Outcomes

As reviewed above, there have been many large cohort studies and randomized trials assessing short- and mid-term outcomes for UFE. However, in the early UFE era, one key question remained unanswered—how durable was the improvement after UFE? Beginning in 2005, long-term outcome studies, with results to 5 years and beyond after UFE began to be published. ► **Table 1** provides a summary of the outcomes of the published long-term studies, including some that now provide outcomes from 8 to 10 years.^{29,38–46}

The first of these studies was by Spies et al, who reported 5-year outcomes on a cohort of 200 consecutive UFE patients,⁴⁴ documenting outcome as measured by symptom status and re-intervention, including hysterectomy, myomectomy, dilatation and curettage, hysteroscopic resection of fibroids, endometrial ablation, or repeat UFE. The protocol defined failure as any patient who underwent subsequent major re-intervention, including hysterectomy, definitive myomectomy, or repeat UFE for any reason, or who experienced no improvement in symptoms after embolization. Dichotomizing symptom control after UFE as either improved or not improved, at 3 month follow-up 93% of patients had improved symptoms, 87% were improved at 12 months, and

Table 1 Long-term follow-up after uterine artery embolization for fibroids

Author	Reference no.	N	Duration of follow-up	% with symptom control	Hysterectomy rate	Recurrence rate ^a
Spies et al	44	200	60 mo (minimum)	73%	13.7%	20%
Walker and Barton-Smith	46	172	60–72 mo	> 80%	5%	16%
Gabriel-Cox et al	38	562	58 mo	80%	19.7%	Not reported
Lohle et al	39	100	54 mo (median)	90%	11%	23%
Popovic et al	41	39	7 y	82.1%	15.4%	Not Reported
Narayan et al	40	89	Range 50–83 mo	Not reported	Not reported	8%
van der Kooij et al ^b	45	88	60	65%	28.4%	35%
Moss et al ^b	29	106	60 mo	68%	19%	32%
Poulsen et al	42	96	Median 8.9 y Range 8–9.4 y	53%	22%	25%
Scheurig-Muenkler et al	43	380	Median 5.7 y Range 3.1–10 y	82%	11%	23.3% cumulative at 10 y

Abbreviations: mo, months; y, years.

^aSubsequent hysterectomy, myomectomy, or repeat uterine embolization for failure to improve or recurrent symptoms.

^bResults are from randomized trial.

85, 83, and 79% were improved at 2, 3, and 4 years after UFE, respectively. The majority (73%) of patients reported improved symptom control for the full 5 years of follow-up. These rates suggest that after approximately 10 to 12% of patients not achieving symptom control at 12 months, there was a subsequent incremental recurrence rate of 3 to 4% per year. Re-interventions were reported in nearly 20% of the patients, with 13.7% of patients undergoing a hysterectomy.

As can be seen in ►Table 1, between 2005 and 2008, four additional studies were published with similar duration of follow-up. These show that between 80 and 90% of patients had long-term symptom control and hysterectomy rates of between 5 and 20%. These results may be contrasted with the 5-year results from both the EMMY and the REST trials. Both these randomized trials included a wide range of practices, with study sites throughout their respective countries. Both these two studies showed higher rates of recurrence (32% for the REST trial and 35% for the EMMY trial) and higher hysterectomy rates (10% for the REST trial and 28.4% for the EMMY trial). Of all the reported studies, recurrence and hysterectomy rates were highest with the EMMY trial. This may in part reflect the relatively high technical failure rate at the time of the UFE, with 18% of patients failing to receive the normal bilateral embolization. Most of the failures in this study occurred within the first 2 years, with 24% of study patients undergoing a hysterectomy by 24 months; an additional 4% of patients had hysterectomies within the subsequent 3 years.

Recently, much longer term outcomes have become available. The recurrence rate in Poulsen et al⁴² was 25% at a median of 8.9 years, with most of these patients having a hysterectomy. Perhaps more interesting is the study by Scheurig-Muenkler et al,⁴³ which showed a cumulative recurrence rate of 23.3% at 10 years, using a survival analysis. They noted that if a patient

did not recur in the early years after embolization then she was unlikely to have a recurrence late, echoing what was found in the study by Spies et al mentioned earlier.⁴⁴ This may in part reflect the onset of menopause in this population. In this latter study, the patients transitioned into menopause at a median of 51 years, the normal median age. For a population that typically has a mean age in their early to mid-40s, recurrence very late may be limited by menopause, and its onset provides the large majority of patients' permanent relief from further symptoms.

Summary

This review provides a reminder that while uterine embolization provides good symptom relief for most patients, there are tradeoffs for patients in terms of short-term outcomes, cost, recovery time, and durability of symptom control when considering the alternative approaches to therapy. However, for a patient with symptomatic uterine fibroids who is done with childbearing, uterine embolization is well established as a safe and effective therapy and should be the first consideration in patients who do not wish to undergo hysterectomy.

Disclosure

The author does not have any disclosures related to this topic.

References

- Goodwin SC, Vedantham S, McLucas B, Forno AE, Perrella R. Preliminary experience with uterine artery embolization for uterine fibroids. *J Vasc Interv Radiol* 1997;8(4):517–526

- 2 Ravina JH, Herbreteau D, Ciraru-Vigneron N, et al. Arterial embolisation to treat uterine myomata. *Lancet* 1995;346(8976):671–672
- 3 Baird DD, Dunson DB, Hill MC, Cousins D, Schectman JM. High cumulative incidence of uterine leiomyoma in black and white women: ultrasound evidence. *Am J Obstet Gynecol* 2003;188(1):100–107
- 4 Myers ER, Goodwin S, Landow W, et al; FIBROID Investigators. Prospective data collection of a new procedure by a specialty society: the FIBROID registry. *Obstet Gynecol* 2005;106(1):44–51
- 5 Goodwin SC, McLucas B, Lee M, et al. Uterine artery embolization for the treatment of uterine leiomyomata midterm results. *J Vasc Interv Radiol* 1999;10(9):1159–1165
- 6 Hutchins FL Jr, Worthington-Kirsch R, Berkowitz RP. Selective uterine artery embolization as primary treatment for symptomatic leiomyomata uteri. *J Am Assoc Gynecol Laparosc* 1999;6(3):279–284
- 7 Spies JB, Scialli AR, Jha RC, et al. Initial results from uterine fibroid embolization for symptomatic leiomyomata. *J Vasc Interv Radiol* 1999;10(9):1149–1157
- 8 Pelage JP, Le Dref O, Soyer P, et al. Fibroid-related menorrhagia: treatment with superselective embolization of the uterine arteries and midterm follow-up. *Radiology* 2000;215(2):428–431
- 9 Brunereau L, Herbreteau D, Gallas S, et al. Uterine artery embolization in the primary treatment of uterine leiomyomas: technical features and prospective follow-up with clinical and sonographic examinations in 58 patients. *AJR Am J Roentgenol* 2000;175(5):1267–1272
- 10 McLucas B, Adler L, Perrella R. Uterine fibroid embolization: nonsurgical treatment for symptomatic fibroids. *J Am Coll Surg* 2001;192(1):95–105
- 11 Spies JB, Ascher SA, Roth AR, Kim J, Levy EB, Gomez-Jorge J. Uterine artery embolization for leiomyomata. *Obstet Gynecol* 2001;98(1):29–34
- 12 Walker WJ, Pelage JP. Uterine artery embolisation for symptomatic fibroids: clinical results in 400 women with imaging follow up. *BJOG* 2002;109(11):1262–1272
- 13 Pron G, Bennett J, Common A, Wall J, Asch M, Sniderman K; Ontario Uterine Fibroid Embolization Collaboration Group. The Ontario Uterine Fibroid Embolization Trial. Part 2. Uterine fibroid reduction and symptom relief after uterine artery embolization for fibroids. *Fertil Steril* 2003;79(1):120–127
- 14 Pron G, Cohen M, Soucie J, Garvin G, Vanderburgh L, Bell S; Ontario Uterine Fibroid Embolization Collaboration Group. The Ontario Uterine Fibroid Embolization Trial. Part 1. Baseline patient characteristics, fibroid burden, and impact on life. *Fertil Steril* 2003;79(1):112–119
- 15 Pron G, Mocarski E, Cohen M, et al. Hysterectomy for complications after uterine artery embolization for leiomyoma: results of a Canadian multicenter clinical trial. *J Am Assoc Gynecol Laparosc* 2003;10(1):99–106
- 16 Spies JB, Coyne K, Guaou N, Boyle D, Skyrnarz-Murphy K, Gonzales SM. The UFS-QOL, a new disease-specific symptom and health-related quality of life questionnaire for leiomyomata. *Obstet Gynecol* 2002;99(2):290–300
- 17 Spies JB, Bradley LD, Guido R, Maxwell GL, Levine BA, Coyne K. Outcomes from leiomyoma therapies: comparison with normal controls. *Obstet Gynecol* 2010;116(3):641–652
- 18 Spies JB, Myers ER, Worthington-Kirsch R, Mulgund J, Goodwin S, Mauro M; FIBROID Registry Investigators. The FIBROID Registry: symptom and quality-of-life status 1. year after therapy. *Obstet Gynecol* 2005;106(6):1309–1318
- 19 Goodwin SC, Spies JB, Worthington-Kirsch R, et al; Fibroid Registry for Outcomes Data (FIBROID) Registry Steering Committee and Core Site Investigators. Uterine artery embolization for treatment of leiomyomata: long-term outcomes from the FIBROID Registry. *Obstet Gynecol* 2008;111(1):22–33
- 20 Broder MS, Goodwin S, Chen G, et al. Comparison of long-term outcomes of myomectomy and uterine artery embolization. *Obstet Gynecol* 2002;100(5 Pt 1):864–868
- 21 Siskin GP, Shlansky-Goldberg RD, Goodwin SC, et al; UAE versus Myomectomy Study Group. A prospective multicenter comparative study between myomectomy and uterine artery embolization with polyvinyl alcohol microspheres: long-term clinical outcomes in patients with symptomatic uterine fibroids. *J Vasc Interv Radiol* 2006;17(8):1287–1295
- 22 Spies JB, Cooper JM, Worthington-Kirsch R, Lipman JC, Mills BB, Benenati JF. Outcome of uterine embolization and hysterectomy for leiomyomas: results of a multicenter study. *Am J Obstet Gynecol* 2004;191(1):22–31
- 23 Pinto I, Chimeno P, Romo A, et al. Uterine fibroids: uterine artery embolization versus abdominal hysterectomy for treatment—a prospective, randomized, and controlled clinical trial. *Radiology* 2003;226(2):425–431
- 24 Hehenkamp WJ, Volkers NA, Donderwinkel PF, et al. Uterine artery embolization versus hysterectomy in the treatment of symptomatic uterine fibroids (EMMY trial): peri- and postprocedural results from a randomized controlled trial. *Am J Obstet Gynecol* 2005;193(5):1618–1629
- 25 Hehenkamp WJ, Volkers NA, Birnie E, Reekers JA, Ankum WM. Symptomatic uterine fibroids: treatment with uterine artery embolization or hysterectomy—results from the randomized clinical Embolisation versus Hysterectomy (EMMY) Trial. *Radiology* 2008;246(3):823–832
- 26 Volkers NA, Hehenkamp WJ, Birnie E, Ankum WM, Reekers JA. Uterine artery embolization versus hysterectomy in the treatment of symptomatic uterine fibroids: 2 years' outcome from the randomized EMMY trial. *Am J Obstet Gynecol* 2007;196(6):e1–e11
- 27 Ananthakrishnan G, Murray L, Ritchie M, et al. Randomized comparison of uterine artery embolization (UAE) with surgical treatment in patients with symptomatic uterine fibroids (REST trial): subanalysis of 5-year MRI findings. *Cardiovasc Intervent Radiol* 2013;36(3):676–681
- 28 Edwards RD, Moss JG, Lumsden MA, et al; Committee of the Randomized Trial of Embolization versus Surgical Treatment for Fibroids. Uterine-artery embolization versus surgery for symptomatic uterine fibroids. *N Engl J Med* 2007;356(4):360–370
- 29 Moss JG, Cooper KG, Khaund A, et al. Randomised comparison of uterine artery embolisation (UAE) with surgical treatment in patients with symptomatic uterine fibroids (REST trial): 5-year results. *BJOG* 2011;118(8):936–944
- 30 Rashid S, Khaund A, Murray LS, et al. The effects of uterine artery embolisation and surgical treatment on ovarian function in women with uterine fibroids. *BJOG* 2010;117(8):985–989
- 31 Ruuskanen A, Hippeläinen M, Sipola P, Manninen H. Uterine artery embolisation versus hysterectomy for leiomyomas: primary and 2-year follow-up results of a randomised prospective clinical trial. *Eur Radiol* 2010;20(10):2524–2532
- 32 Mara M, Fucikova Z, Maskova J, Kuzel D, Haakova L. Uterine fibroid embolization versus myomectomy in women wishing to preserve fertility: preliminary results of a randomized controlled trial. *Eur J Obstet Gynecol Reprod Biol* 2006;126(2):226–233
- 33 Mara M, Maskova J, Fucikova Z, Kuzel D, Belsan T, Sosna O. Midterm clinical and first reproductive results of a randomized controlled trial comparing uterine fibroid embolization and myomectomy. *Cardiovasc Intervent Radiol* 2008;31(1):73–85
- 34 Manyonda IT, Bratby M, Horst JS, Banu N, Gorti M, Belli AM. Uterine artery embolization versus myomectomy: impact on quality of life—results of the FUME (Fibroids of the Uterus: Myomectomy versus Embolization) trial. *Cardiovasc Intervent Radiol* 2012;35(3):530–536
- 35 Jun F, Yamin L, Xinli X, et al. Uterine artery embolization versus surgery for symptomatic uterine fibroids: a randomized controlled trial and a meta-analysis of the literature. *Arch Gynecol Obstet* 2012;285(5):1407–1413

- 36 van der Kooij SM, Bipat S, Hehenkamp WJ, Ankum WM, Reekers JA. Uterine artery embolization versus surgery in the treatment of symptomatic fibroids: a systematic review and metaanalysis. *Am J Obstet Gynecol* 2011;205(4):e1–e18
- 37 Gupta JK, Sinha A, Lumsden MA, Hickey M. Uterine artery embolization for symptomatic uterine fibroids. *Cochrane Database Syst Rev* 2012;5:CD005073
- 38 Gabriel-Cox K, Jacobson GF, Armstrong MA, Hung YY, Learman LA. Predictors of hysterectomy after uterine artery embolization for leiomyoma. *Am J Obstet Gynecol* 2007;196(6):e1–e6
- 39 Lohle PN, Voogt MJ, De Vries J, et al. Long-term outcome of uterine artery embolization for symptomatic uterine leiomyomas. *J Vasc Interv Radiol* 2008;19(3):319–326
- 40 Narayan A, Lee AS, Kuo GP, Powe N, Kim HS. Uterine artery embolization versus abdominal myomectomy: a long-term clinical outcome comparison. *J Vasc Interv Radiol* 2010;21(7):1011–1017
- 41 Popovic M, Berzaczy D, Puchner S, Zadina A, Lammer J, Bucek RA. Long-term quality of life assessment among patients undergoing uterine fibroid embolization. *AJR Am J Roentgenol* 2009;193(1):267–271
- 42 Poulsen B, Munk T, Ravn P. Long-term follow up after uterine artery embolization for symptomatic uterine leiomyomas. *Acta Obstet Gynecol Scand* 2011;90(11):1281–1283
- 43 Scheurig-Muenkler C, Koesters C, Powerski MJ, Grieser C, Froeling V, Kroencke TJ. Clinical long-term outcome after uterine artery embolization: sustained symptom control and improvement of quality of life. *J Vasc Interv Radiol* 2013;24(6):765–771
- 44 Spies JB, Bruno J, Czeyda-Pommersheim F, Magee ST, Ascher SA, Jha RC. Long-term outcome of uterine artery embolization of leiomyomata. *Obstet Gynecol* 2005;106(5 Pt 1):933–939
- 45 van der Kooij SM, Hehenkamp WJ, Volkers NA, Birnie E, Ankum WM, Reekers JA. Uterine artery embolization vs hysterectomy in the treatment of symptomatic uterine fibroids: 5-year outcome from the randomized EMMY trial. *Am J Obstet Gynecol* 2010;203(2):e1–e13
- 46 Walker WJ, Barton-Smith P. Long-term follow up of uterine artery embolisation—an effective alternative in the treatment of fibroids. *BJOG* 2006;113(4):464–468