Advancements in Minimally Invasive Treatments for Female Stress Urinary Incontinence: Radiofrequency and Bulking Agents

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Continuous advancements in materials technology have provided the possibility that multiple new urethral bulking agents will be available soon. Experience continues to accrue in clinical trials for urethral bulking with these agents. Parallel use for the indication of pediatric vesicourethral reflux also has provided evidence of biologic activity related to these compounds. All of the agents closest to complete analysis are synthetic and represent a variety of material types and characteristics. As these materials evolve, understanding of the preferential injection technique is being gained. Delivery methods and sites may prove to alter the biologic activity of these compounds substantially. Emphasis on other minimally invasive options for the surgical treatment of stress incontinence also has resulted in the development of radiofrequency vesicourethral suspension. Improved understanding of thermal application to tissue, acute and chronic tissue response to this application, and accumulating human experience with this method of therapy has provided an acceptable tolerability profile for this therapy. This profile may provide application of this method of therapy to an in-office treatment setting, precluding hospitalization and substantially decreasing convalescence times.

Introduction

Genuine stress urinary incontinence (GSUI) continues to become an increasingly significant health concern for millions of women. Approximately 180,000 surgical procedures are performed for GSUI according to recent estimates. The lack of one single, reproducible, permanent and minimal risk procedure has led to the development of several minimally invasive options that provide the hope of reasonable efficacy associated with minimal morbidity. Reimbursement trends also have placed an emphasis on interventions that require minimal hospitalization or, more optimally, can be performed entirely in the ambulatory office location without requirements for general or regional anesthesia and attendant recuperative facilities.

Bulking therapy has been used for the management of GSUI for more than a decade, but has been limited by durability and antigenicity issues associated with bovine collagen. Approval of carbon particulate technology by the US Food and Drug Administration (FDA) has provided another option for bulking, but one that is somewhat limited by injection difficulty (because of carrier extrusion resulting in injection needle obstruction). Because of these concerns, many physicians use this material in the controlled setting of the operative suite only, thus detracting from the financial benefit associated with in-office bulking therapy. Therefore, the use of bulking therapy has been less than optimal. However, the advent of several new bulking agents (each with unique tissue interaction characteristics and each individually holds the promise of greater durability), with fewer actual injection sessions and no antigenicity, promises to dramatically alter the role of bulking therapy in the overall management schema for GSUI. The selection of patients appears crucial to the outcome of the intraurethral injection of bulking agents. The ideal candidate for this procedure is one who has good anatomic support, a compliant, stable bladder, and a malfunctioning urethra evidenced by a low leak point pressure. Other subsets of patients who may benefit from the procedure are patients with high leak point pressure and minimal hypermobility and elderly women with bladder base mobility who are less active and are at a poor surgical risk for other interventions.

In addition, the use of different types of procedures for the surgical management of GSUI continue to be investigated. These procedures lend themselves to the ambulatory or office setting, while mimicking the efficacy and safety profiles of available procedures (*eg,* slings or suspensions). The advent of radiofrequency (RF) as a treatment modality for solid tumor lesions in solid organs and for benign indications such as orthopedic joint capsule therapy has led to improved understanding of this thermal delivery system and its effects on soft tissue structures. Investigation into RF

energy delivery in initial animal experiments and relatively large scale human experience has shown the potential of this modality to be another minimally invasive option for selected women with GSUI.

Injectable Agents

The successful use of periurethral bulking agents depends on several factors inclusive of the composition of the material, facility of agent use (ease of preparation and implantation), and a receptive host environment (optimized hormonal environment, integrity of urethral mural components, and intact periurethral fascia). Three categories of materials have been investigated for periurethral bulking: human (autologous or allograft), xenograft, and synthetic.

The optimal attributes for bulking materials are biocompatibility, minimal or no immunogenicity (hypoallergenic), and integrity of the material formulation (there should be little or no separation of agent subcomponents; carrier and particulate solid). Rheologic (deformation within tissue) characteristics of the agent also should be affected positively by adequate material viscosity and surface tension and tissue response (wound healing) instigated by the agent should be reproducible. Tissue response characteristics should further demonstrate minimal fibrotic ingrowth and little extracapsular inflammatory response (if encapsulated); agent volume after injection should be retained with minimal resorption. The most ideal scenario for any putative soft-tissue bulking agent would be a single injection with permanent tissue residence of the agent (and partial or total incorporation into the host tissues). However, the reality for the available agents is that they do not fulfill these criteria ideally because of isolated or combined agents and host factors (*ie,* lack of resorption, agent admixture separation).

Durasphere (Carbon Medical Technologies, St. Paul, MN) pyrolytic carbon-coated zirconium oxide beads were approved by the FDA in 1999. The beads are suspended in a water-soluble β-glucan vehicle. The randomized, multicenter, double-blind study accepted by the FDA compared collagen with Durasphere and showed similar outcomes, with Durasphere offering a slight benefit. Durasphere is more viscous than collagen; therefore, its injection is technically more demanding.

Renewed concern has been expressed regarding material migration after injection. Microcrystalline components of the bulking agent should be composed of uniform spheroidal particles with sizes higher than 110 microns (approximate size required to avoid migration). Migration is influenced by the ability of host macrophages to phagocytize particles; smaller particle sizes have been shown to migrate to distant locations with Teflon injection (Fluorten, Italy). However, direct embolization of material is caused by high-pressure injection resulting in material displacement into vascular or lymphatic spaces. Recent reports of carbon particulate migration likely represent the result of high-pressure introduction of particulate material into the vascular system. Therefore, the injection technique should rely on larger particle sizes administered with low-pressure injection instrumentation [1].

Specific agents in development

Synthetic calcium hydroxylapatite is identical to the same material found in human teeth and bones. The agent is composed of hydroxylapatite spheres (which are extremely uniform in shape, smooth, and 75–125 microns in size) in an aqueous gel composed of sodium carboxymethylcellulose. Plain film radiography or ultrasonography may be used to localize this material and can be useful adjuncts to assessing implantation. The first FDA-approved indication for this material has been obtained and is for soft tissue marking (as an adjunct to radiographic focusing for radiotherapeutics). Agent injection is carried out with a small bore (21-gauge needle), with standard cystoscopic instruments. A large-scale North American pivotal trial continues to be performed. This study will accrue more than 250 women. Thus far, 21 women have received carboxymethylcellulose and 18 received collagen and have been followed for 1 year since the last injection [2]. The average number of injections was 2.0 for carboxymethylcellulose and 2.3 for collagen. The total volume injected was 3.7 mL for carboxymethylcellulose and 7.4 mL for collagen. Eighty-six percent of the patients who were administered carboxymethylcellulose improved by at least one Stamey grade, 67% improved by two grades, and 38% were completely continent (compared with women who received collagen with 66%, 55%, and 44%, respectively). Overall, pad weight reduction (1-hour stress pad test) was 75% in 77% and 55% of carboxymethylcellulose and collagen patients, respectively, and was 90% in 46% (carboxymethylcellulose) and 33% (collagen), respectively. No prolonged retention, urgency, or periurethral erosion or abscess was seen in either group. This agent has similar injection characteristics to collagen and appears to require less injected volume for somewhat more durable effects than collagen.

Another biologic agent, cross-linked hyaluronic acid (HA), is a water insoluble, complex glycosaminoglycan composed of disaccharide units, which form molecules of 23 million molecular weight, and is dissolved in normal saline for urethral bulking purposes. This composite gel has significant elasticity and high viscosity. These biologic characteristics have led to the use of hylan gels for soft tissue bulking purposes. It is completely biodegradable and nonimmunogenic. HA functions as the transport compound and is resorbed within 2 weeks after injection. The dextranomer microspheres actually function as bulking agents and are 80 to 200 microns in size and do not show fragility with insertion, remaining in the injection site for approximately 4 years. Injection is performed using standard cystoscopic equipment, with minimal injection pressure. A clinical trial has been promulgated to evaluate this agent for GSUI. However, substantive data exist for the efficacy and safety of this agent for the indication of vesicoureteral reflux and for pediatric incontinence.

Results of the dextranomer injection for pediatric incontinence show no associated adverse events and substantial improvement at 12 months after the injection [3]. Sixteen patients (with a variety of underlying etiologies for their incontinence) underwent a mean of 2.3 injections with a mean volume of 2.8 mL with subsequent annual follow-up. Seventy-five percent were improved at 6 months and 50% at 12 months (this was determined by 1-hour pad tests and diary data). Further follow-up at 2 years indicated relative stability of incontinence parameters compared with the 1-year data. No local injection site complications or immunologic sequelae resulted. Similar durability and safety findings have been identified with this material when used for the reflux indication.

Synthetic agents pose a potential benefit as bulking agents because of their stability (non-biodegradability). Silicone is a hydrogel suspension composed of polyvinylpyrrolidone (povidone) as the carrier (which also acts as a lubricant for the injection system); the bulking agent is solid polydimethylsiloxane elastomer (vulcanized silicone). The elastomer is a particulate of various shapes and conformal configurations. Particle size is markedly variable, with 25% of the particles being less than 50 microns in size and some are more than 400 microns in largest dimension. Silicone delivery requires high pressure administration; however, with newer equipment, this material is more easily delivered. Although well established in Europe, concerns regarding silicone stimulation of the immunologic response have limited the evaluation of this agent in the United States. However, a clinical trial evaluating this agent (Macroplastique, Uroplasty, the Netherlands) is in progress in North America. A recent Scandinavian report observed 22 women (2 years after the injection) who were administered this agent [4]. Subjective and objective criteria showed stability and persistent benefit for those patients. Overall pad test data showed dramatic reduction (147 g mean before treatment to 9 g after treatment). No long-term local or systemic complications were noted.

Ethylene vinyl alcohol copolymer suspended in dimethyl sulfoxide (DMSO) or Uryx (C. R. Bard, Inc., Murray Hill, NJ) solution is being evaluated as an embolic agent and a bulking agent. On injection and exposure to solution (blood or extracellular space) at physiologic temperatures, the DMSO diffuses from the copolymer and causes the ethylene vinyl alcohol to precipitate into a complex spongiform mass. This phase change requires diligent separation of the agent and body temperature fluids until implantation occurs. Early experience with this agent suggested that optimal results were obtained with injection in a more distal urethral location within the urethra (approximately 1.5 cm distal to the bladder neck), with a slower rate of injection (at least 30 seconds/injection site), and without the need to observe visual coaptation at the completion of injection. Using these end point criteria, results with this agent have been intriguingly good. An interesting difference with this material is that injection is a set volume, not an end point of coaptation of the urethra/bladder neck at the time of injection.

A large scale North American trial is in progress. The trial incorporates 219 women with GSUI and uses a prospective, randomized (2:1 Uryx to bovine collagen) schema [5]. The study has finished accrual and all of the treated patients will be followed for 1 year after the last injection. At 6 months, 40 patients in the Uryx arm and 23 in the collagen arm have been evaluated at 12, 21, and 13 months, respectively. Thus far, the mean total volume of material required for injection has been less for Uryx (4.4 mL compared with 6.9 mL for collagen). At 6 months, 63% of Uryx patients were dry (no incontinent episodes) compared with 48% of the collagen patients. At 12 months, 74% of the Uryx patients were dry compared with 40% of the collagen patients. Rates of post-implantation urgency and dysuria essentially were the same between the two arms. This result suggests that, unlike collagen, Uryx maintains a durability of response that is not noted with biologic agents and may provide the first synthetic material to do this without substantive complication issues.

A requirement for FDA trials with these agents is active comparison with bovine collagen. No current head-to-head data exist between these evolving agents for the indication of GSUI. However, a recently completed trial compared Macroplastique (Uroplasty, the Netherlands) with dextranomer/HA for the treatment of ureteral reflux in children [6].

Radiofrequency Therapy for Genuine Stress Incontinence

Radiofrequency bladder neck suspension relies on a unique form of electromagnetic energy (RF energy) that produces reproducible thermal changes in soft tissues, which are manifested by tissue heating and coagulation. RF energy delivery has been used extensively in other specialty fields including dermatologic and orthopedic indications for tissue ablation or remodeling [7].

Soft tissue studies in animals (mini pigs) have revealed reproducible and defined effects from RF energy delivery to soft tissue structures [8•]. Acute effects associated with RF energy include denaturation of collagen fibrils with initial resultant loss of collagen fibril integrity. Associated with the change in collagen fibers, an acute inflammatory response occurs during this time frame. The inflammatory cellular infiltrate gradually matures and acute elements are replaced by macrophages and lymphocytes. Within 7 days after thermal injury, a generalized granulation response is seen, which is followed by a fibroblastic response noted by the third week after treatment. At 6 weeks after therapy, the fibrotic response stabilizes with maturation of the fibrosis and the disappearance of the acute and chronic inflammatory cellular infiltrate. Thermal penetration is 2 to 3 mm with the developed devices. The final histologic result produced is a fibrotic replacement

of the weakened elastic endopelvic fascia. No significant tissue calcification has been noted during chronic histologic surveillance of treated animal tissues. The overall mechanical effect produced by RF energy delivery is that fascia becomes stiffened and thickened, thus recapitulating bladder neck and urethral support characteristics. Additionally, collagen mechanical strength returns to 80% of its overall tensile resistance at approximately 6 weeks after therapy application.

Refinement in instrumentation has produced RF devices that have relatively small silhouettes and are ergonomically designed to allow for different surgical approaches. These devices produce an extremely localized tissue effect and only result in heat penetration with subsequent tissue effect of 2 to 3 mm. This generation of devices produces no deep tissue heating or collagen change, thereby protecting underlying visceral structures (*ie,* urinary bladder and urethra).

Two recent studies have reviewed the overall responses to RF therapy in women with stress urinary incontinence. Laparoscopic and transvaginal approaches have been evaluated in these trials and are FDA-approved and available.

Transvaginal Trial

The transvaginal therapy trial was a prospective, multicenter, single-arm investigational evaluation of 120 women with a history of GSUI who had associated urethral hypermobility [9••]. Preoperative evaluation included a history, physical examination, voiding diary, quality-of-life questionnaire, and urodynamics. Patients were excluded if they had higher than grade 2 cystoceles or other vaginal or uterine support defects. Patients were included if the hypermobility of the proximal urethra and bladder neck was greater than 30° and if their associated valsalva leak point pressures were greater than 90 mL of water at a bladder capacity of 250 mL. Detrusor instability and compliance abnormalities also were excluded with cystometric evaluation.

All of the patients were treated with a transvaginal system manufactured by SURX (Livermore, CA). The device consisted of a generator and an associated applicator, which has a handle and a trigger mechanism for activation purposes. The RF delivery is produced by a 270°-rotational tip that contains microbipolar electrodes and a port to allow continuous saline irrigation of the distal end of the device during treatment (for thermal regulation). A thermistor is located between the electrodes to continuously monitor tissue temperature during RF application.

For this trial, all of the patients were treated with general anesthesia. The procedure briefly involved placing the anesthetized patient in the dorsal lithotomy position with a Foley catheter inserted into the bladder. Two- to 3-cm incisions were created on the anterior vaginal wall, 1 cm lateral to the urethra, on either side at the level of the junction between the proximal urethra and the bladder neck. The lateral vaginal wall then was dissected away from the underlying endopelvic fascia to expose a 1.5 x 2 cm area of the inferior aspect of the endopelvic fascia. The endopelvic fascia was left intact during the dissection (the fascia was not disrupted). A similar dissection was preformed on the contralateral side. Once complete exposure was obtained, meticulous hemostasis was assured. The tip of the RF applicator then was applied to the underlying endopelvic fascia in a slow sweeping manner along the exposed endopelvic fascia to ensure adequate applicator tip contact with the underlying tissues. No direct RF application was applied to the urethra itself. During treatment, thermal effect was noted by tissue blanching and contraction. Tissue charring was avoided. Once treatment was completed on both sides of the bladder neck, the vaginal incisions were closed with running, absorbable tissue.

The treatment protocol provided for patient follow-up at 1 week, followed by 1, 3, 6, and 12 months after surgery. During follow-up visits, a history, physical examination, repeat urodynamic evaluations (6- and 12-month visits only), a voiding diary, and quality-of-life questionnaire assessments were performed. Primary endpoints of the study were physician and patient assessment of continence, safety of the procedure, and patient recorded daily incontinence episodes. For the purposes of this study, treatment "cure" was defined as no incontinence associated with maximal valsalva effort on physical examination and urodynamics. Patients were classified as improved if they experienced decreased daily episodes of urinary incontinence and were subjectively better on quality-of-life assessments.

A total of 120 women were treated in this study. All of the patients fulfilled urodynamic and hypermobility criteria specified previously. Average operative time was 30 minutes, with an average RF treatment per side of approximately 2 to 3 minutes. Tissue impedance during treatment averaged 204 ± 66 ohms at an average temperature 82 ± 8° centigrade.

There were no complications incurred intraoperatively; however, three short-term minor complications were encountered within the first month. One vaginal incision disruption occurred, which required a repeat closure at 3 weeks. Another patient experienced a urinary tract infection and another experienced transient urgency at 1 month, which resolved by the 30-month follow-up visit.

Ninety-six patients completed the 12-month follow-up examination. Treatment success, which was defined as cured or improved, was 73% at 12 months. One hundred nine patients underwent repeat urodynamics. Of those patients, 66 (61%) had negative valsalva determination on urodynamic evaluation at 12 months (intent to treat analysis includes patients who did not return for follow-up study as failures). If only the patients who actually underwent urodynamics at the 12-month time frame are considered, 76% had negative leak point pressures. When considering the outcome of daily incontinence episodes, 64% of the patients reported reduced episodes of incontinence. External absorbent pad usage decreased substantially after therapy; 57% of the patients used one or more pads daily before treatment, but only 28% used one pad or more after treatment. Patient satisfaction was evaluated using a Likert-type scale. With this methodology, 68% of patients reported satisfaction with the outcome of the

procedure at 12 months and most of the patients reported substantial improvement in the overall quality of life at the 12-month evaluation compared with baseline analysis.

No chronic complications were encountered. Specifically, no long-term manifestation of urinary tract injury, such as urinary fistula or severe urgency, was identified after treatment.

Laparoscopic Trial

In a separate trial, the effects of laparoscopic RF treatment of the endopelvic fascia also were evaluated [10••]. In this prospective multicenter trial, 94 women (mean age, 48 years) who had similar hypermobility and leak point criteria to the transvaginal group (above) were treated with RF energy applied to the endopelvic fascia using a laparoscopic approach. Treatment follow-up was similar to the transvaginal protocol-specified time periods and parameters.

After inserting abdominal laparoscopic instrumentation (trochars, dissecting forceps) in an extraperitoneal location, the space of Retzius was balloon dissected and the pelvic floor was identified. Adipose tissue was removed from the visceral surface of the endopelvic fascia to improve visualization of the periurethral tissues. The RF probe then was placed through the laparoscopic working port and positioned on the periurethral endopelvic fascia. Vaginal manual manipulation was used simultaneously to assist and control the probe during laparoscopic application (allowing bimanual tactile feedback during tissue heating). Tissue impedance and temperature criteria similar to the transvaginal protocol were used for this treatment. During treatment, tissue shrinkage and blanching were observed again.

For these 94 women, the average operative time was 54 minutes, with a total RF application time of 2.2 minutes/side. Tissue impedance averaged 186 ohms and average temperature measured by RF probe thermistor was 89°C. Average tissue surface area contraction after treatment was 17% in length and 21% in width (compared with visual inspection before RF application).

At the 12-month follow-up, 78% of the patients had no urinary incontinence, which was demonstrated by valsalva effort on examination or urodynamics. Moreover, no changes in other urodynamics criteria such as compliance, sensation, or emergence of de novo detrusor overactivity were noted after therapy. One patient reported new onset of sensory urgency that persisted at 12 months. At 12 months, the continent and improved rate was 81% (using previously stated criteria). In addition, 77% of the patients reported no or one incontinent episode daily when the study was completed compared with baseline. Quality of life and patient approbation of the procedure also substantially changed after therapy, with 81% of the patients having significant improvement at 12 months and 83% being satisfied with the overall results.

Complications of the procedure included four intraoperative events (4.3%). Two of these cases were related to bladder perforation during attempted laparoscopic access for the RF device before thermal energy was applied. One patient experienced hypertension while under anesthesia and another developed a pelvic hematoma after dissection. Both of these events were thought to be unrelated to thermal application. Ninety-eight percent of the patients were able to be discharged from the day surgery unit.

Five patients (5.3%) developed complications after the surgery. One patient developed a trochar site infection and another developed urinary urgency after treatment. Two women developed symptomatic urinary tract infections that required antibiotics and one had postoperative nausea and vomiting that were related to anesthesia.

Both study groups experienced substantial benefit with RF energy application to the endopelvic fascia. Additionally, this benefit was experienced without substantial side effects or complications. Most remarkably was that no severe thermal effects were noted after the operation.

On-going evaluation of these techniques reveals that, at the minimum 2-year follow-up, treatment benefit continues to be maintained at levels similar to the 1-year findings. No emergent complications have resulted during this time frame. More than 300 RF suspensions (most of them being transvaginal) have been performed since they were approved by the FDA.

Because of the substantially positive therapeutic index for RF suspension, new techniques are evolving for RF application. The transvaginal approach is now being performed solely under a local anesthesia in office settings. A completely transvaginal, no incision device is being tested actively. The goal of this device will be thermal application through the intact vaginal epithelium. RF energy characteristics allow thermal focusing to be accomplished in this manner; a clinical trial is on-going using such an approach. A different device is being studied in clinical trials that uses RF energy delivered by a transurethral technique. This device uses needle-like prongs, which are displaced from the RF probe after urethral placement. These prongs create a focal area of thermal effect in the endopelvic fascia immediately outside of the periurethral fascia. Preliminary results are promising thus far with specific instrumentation.

Conclusions

Rapid advancements in the development of bulking agents with reproducible effects when implanted from the tissue response (wound healing) and from the efficacy standpoint continue to occur. Chronic evaluation is demonstrating the superiority of at least some of these agents compared with bovine collagen with regard to long-term durability and efficacy. The convenience of local anesthesia, essentially no implantation after convalescence, and minimal voiding dysfunction coupled with the efficacy benefits mentioned previously are leading to the emergence of these agents as potentially better therapeutic options for women with GSUI.

Radiofrequency energy represents a relatively new therapeutic modality for the surgical management of GSUI. RF application results in reproducible tissue effects, which have

provided substantial improvement for women with GSUI, with minimal short-term and essentially no long-term complications. Improved delivery systems may allow this procedure to become an entirely office-based intervention. It appears that patients with combined proximal urethral hypermobility and higher leak point pressures represent the best candidates for this therapy.

References and Recommended Reading

Papers of particular interest, published recently, have been highlighted as:

- • Of importance
- •• Of major importance

1. Ritts RE: **Particle migration after transurethral injection of carbon coated beads.** *J Urol* 2002, **167:**1804–1805.
2. Dmochowski R, Appell RA, Klimberg I, Mayer R: **Initial clinical results from Coaptite injection for stress urinary incontinence, comparative clinical study.** *Presented at the International Continence Society.* Heidelberg, Germany: August 27, 2002.
3. Caione P, Capozza N: **Endoscopic treatment of urinary incontinence in pediatric patients: 2-year experience with dextranomer/hyaluronic acid.** *J Urol* 2002, **168:**1868–1871.
4. Peeker R, Edlund C, Wennberg AL, Fall M: **The treatment of sphincter incontinence with periurethral silicone implant (macroplastique).** *Scand J Urol Nephrol* 2002, **36:**194–198.
5. Dmochowski RR, Herschorn S, Corcos J, *et al.*: **Multicenter randomized controlled study to evaluate Uryx urethral bulking agent in treating female stress urinary incontinence.** *J Urol* 2002, **167:**LB–L10.
6. Aboutaleb H, Bolduc S, Upadhyay J, *et al.*: **Subureteral polydimethylsiloxane injection versus extravesical reimplantation for primary low grade vesicoureteral reflux in children: a comparative study.** *J Urol* 2002, **169:**313–316.
7. Hecht P, Hayashi K, Lu Y, *et al.*: **Monopolar radiofrequency energy effects on joint capsular tissue: potential treatment for joint instability: an in vivo mechanical, morphological, and biochemical study using an ovine model.** *Am J Sports Med* 1999, **27:**761–771.
8. • Galen DL: **Histologic results of a new treatment for stress urinary incontinence without implantable materials.** *Obstet Gynecol* 2000, **95:**S30.

Rabbit-based model emphasizing the reproducible effects of RF energy on the endopelvic fascia and the lack of visceral injury induced by this thermal application.

9. •• Dmochowski RR, Avon M, Ross J, *et al.*: **Transvaginal radiofrequency treatment of the endopelvic fascia: a prospective evaluation for the treatment of genuine stress urinary incontinence.** *J Urol* 2003, **169:**1028–1032.

First analysis of TV RF energy delivery and its effect on symptomatic stress urinary incontinence.

10. •• Fulmer BR, Sakamoto K, Turk TM, *et al.*: **Acute and long-term outcomes of radio frequency bladder neck suspension.** *J Urol* 2002, **167:**141–145.

Well-designed study reporting the first large-scale RF experience in humans using the laparoscopic RF treatment approach.