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Long-Term Results of Autologous Venous Grafts for Penile Morphological Reconstruction

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Abstract

In order to evaluate the long-term results of autologous venous grafts, we present an overview of patients who underwent a procedure utilizing a venous patch from the deep dorsal vein with or without combination of the cavernosal vein in treating penile deformity. From March 1995 to March 2005, a total of 85 consecutive patients with Peyronie disease or congenital penile deviation underwent venous grafting. Tunical corporotomy was covered using transplanted venous wall sutured microscopically to collagen bundles of the inner circular and outer longitudinal layer of the tunica albuginea. The vein was sutured with the serosal side outward, after it had been detubularized, properly constructed, and spliced together. In this cohort, 48 patients with Peyronie disease and 37 with congenital penile deviation were respectively categorized as belonging to the Peyronie and congenital groups. All patients were evaluated preoperatively and postoperatively with the International Index of Erectile Function (IIEF-5) scoring, angle measurement of erectile penis, satisfaction with the penile shape, and a cavernosogram which was further available for 15 patients. Histological confirmation in 5 cases was followed up for up to 10 years. The mean angle improvement was 44.8 ± 3.6° for the Peyronie group and 37.6 ± 3.8° for the congenital group. A satisfactory penile shape was achieved in 77 (90.6%) patients, although 8 men (9.4%) complained of mild deviation of the penis (<15°). Erectile function was good in 81 patients, although 6 of them had to use oral sildenafil/tadalafil

postoperatively. Overall, they had a mean preoperative IIEF-5 score of 19.7 ± 2.8, which increased to a mean postoperative score of 21.6 ± 2.2. The cavernosograms consistently disclosed a good penile shape. The histological confirmation showed that the donor vein retained its histological character despite the fact that perfect coalescence and lining up with the tunica albuginea were noted. The autologous vein appears to be an acceptable graft material, and the transplanted vein may have a modeling action rather than a scaffolding role in venous patch surgery on the penile tunica albuginea. Careful microsurgical manipulation is required to achieve a satisfactory, sustainable outcome.

Key words: Peyronie disease, congenital penile deviation, deep dorsal vein, cavernosal vein, venous grafting

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The human penis is a unique structure composed of multiple fascial layers which surround the 3 cylinders of the erectile sinusoids. It consists of the glans penis, the corpus spongiosum with the bulb of the urethra, the paired corpora cavernosa, and the ischiocavernosus and bulbospongiosus muscles. It has been widely studied, and it is generally accepted that its anatomy is well established (Tudoriu and Bourmer, 1983; Gray, 1989; Goldstein and Padma-Nathan, 1990; Wespes et al, 1990; Putz and Pabsteds, 2001). The tunica albuginea of the corpora cavernosa is consistently described as a single layer with uniform circumferential thickness (Alexander and Carson, 2003; Eardley and Sethia, 2003). It has, however, been elucidated that a complete inner circular layer and an incomplete outer longitudinal layer characteristically encloses and supports the sinusoids of the corpora cavernosa (Hsu et al, 1992; Hsu et al, 2004b; Hsu et al, 2005). In the entire human body, it is the most ideal milieu to apply Pascal's principle, which describes how a change in the pressure applied to an enclosed incompressible fluid is transmitted, undiminished, to every portion of the fluid and to the walls of the containing vessel if no venous leakage exists (Halliday, 1997). Hence this intriguing knowledge of the tunica is deemed to be a prerequisite for every surgeon who intends to operate on this delicate structure, since the tunica albuginea acts physically as the wall (Hsu, 2006).

There are many reasons and purposes for operating on the penis. It is generally acceptable to destroy the erectile capability if surgery is required to eradicate a cancerous entity. In contrast, however, if an operation designed for reconstruction will reduce erectile capability or compromise the penile morphology, then it may draw protests from the patient (Lue, 1989; Hauri, 1999; Porena et al, 2002); surgeons, therefore, should make every effort to preserve erectile function and a normal penile shape.

Surgical intervention for mature Peyronie disease might be a good solution for this complicated disease entity (Levine et al, 1986; Gholami and Lue, 2002). Graft surgery may be the optimal option. Although many kinds of resources have been reported as graft materials for tunical patches (Devine and Horton, 1974; Bruschini and Mitre, 1979; Dad and Amar, 1982; Lowe et al, 1982; Collins, 1988; Gelbard and Hayden, 1991; Schwarzer et al, 2003; Schultheiss et al, 2004), autologous venous material has been recommended as an optimal resource for covering a corporotomy defect due to its histological and functional compatibility (Fournier et al, 1993; Moriel et al, 1994; Kim and McVary, 1995; Montorsi et al, 2000). Similarly, in patients with congenital penile deviations undergoing curvature corrections, further shortening of the postoperative penis should be avoided by all means. This is a problem that can be solved through grafting. The sufficiency of the deep dorsal vein (DDV) is controversial (Jordan et al, 1998; Hsu, 2006), but it might be sufficient after our procedures proved it with 2 scientific formulas rather than the traditional "rule of thumb" (Hsu, 2006). A concern over its long-term outcome has recently been raised. Further scientific research is warranted in order to elucidate this dilemma.

It is impossible to overstress the importance of properly suturing targeted tissues together, which is crucial to the success of any type of surgery. With surgery of the tunica albuginea, which is an extraordinarily delicate structure to work with, it is advisable to use a loupe in order to ascertain whether the transplanted venous wall and the collagen bundle of the inner circular as well as the outer layer can be sutured together precisely and firmly. Herein we report our results for this cohort of 85 consecutive men.

Materials and Methods

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From March 1995 to March 2005, a total of 85 consecutive patients with Peyronie disease or congenital penile deviation underwent autologous venous grafting from the deep dorsal vein, either with or without the combination of the cavernosal vein (CV), to correct their penile morphology. Among these, 48 patients with Peyronie disease and 37 with congenital penile deviation were respectively categorized as belonging to the Peyronie and congenital group. These patients were aged from 21 to 76 (mean, 56.8 ± 9.2) years and with penile deviations from 30° to 90°, which prevented them from performing normal coitus. Their degrees of penile curvature or deformity in erectile state were measured preoperatively and postoperatively. A prostaglandin E1 (PGE1)-induced erection was used if patient could not attain erection with visual aids. A cavernosogram was routinely made if patients complained of erectile dysfunction preoperatively (Figure 1A), and one was made postoperatively for follow-up (Figure 1B) in 15 patients. Patients were excluded from participation in the study because of untreated chronic systemic disease or other obvious etiologies (eg, diabetes mellitus, renal failure, psychiatric problems, or hormonal insufficiency).

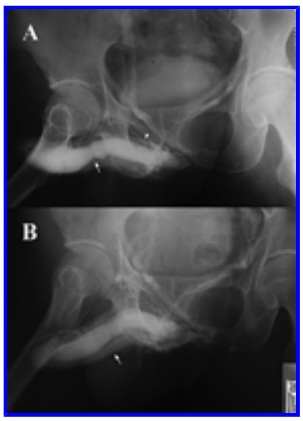

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Figure 1. Representative photos in the Peyronie group. **(A)** Pharmacocavernosograms of a 56-year-old liver transplant patient in the Peyronie group. Film of the preoperative state disclosing that the penile morphology was torque (arrow) and looked like a goose neck due to Peyronie process, which was believed to be mature, since this patient had suffered the disease entity for 3 years. Note that the deep dorsal vein (DDV) (arrowhead) can clearly be seen in this pharmacocavernosogram, despite the fact that 20 µg of prostaglandin E1 was intracavernously injected for 30 minutes. Is this evidence of veno-occlusive dysfunction? Thus his 3 years' associated erectile dysfunction can be explained. **(B)** A voluntary film taken 4 years postoperatively after the detubularized DDV and cavernosal veins (CV) were adequately spliced and constructed. The penile shape was no longer torque, and the erectile capability was satisfactory postoperatively. The corpus spongiosum (arrow) had become a major route of blood return. Note that its centrally located radiolucent zone is the urethra.

The erectile capabilities of these patients were assessed using scores of the abridged 5-item version of the International Index of Erectile Function (IIEF-5) preoperatively. In the Peyronie group, 2 patients subsequently received a penile implant to treat their annoying erectile dysfunction (ED), and 1 patient received a second surgery for venous grafting. In the congenital group, 2 patients underwent curvature correction for the second time with a simple Nesbit procedure because of overcorrection resulting from applying an excessive amount of venous material (Figure 2) during grafting 2 and 4 years postoperatively, respectively. One patient eventually underwent a

penile implant in order to treat the ED resulting from pelvic trauma.

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Figure 2. Representative photos in the congenital group. **(A)** Ventral view, a picture of the erect penis of a 23-year-old patient in the congenital group. This is obviously a situation of left lateral curvature. We accordingly used an autologous venous patch with the deep dorsal and cavernosal veins in this patient. **(B)** Ventral view, photo taken 1 year postoperatively. An obvious ballooning area can clearly be seen. It was the result of an overcorrection in which an excessive amount of venous material had been applied for grafting during the previous surgery. It was not acceptable, although the total volume of the corpora cavernosa was expanded. We decided that a second revision was indicated, which was subsequently carried out, since the patient consistently disliked his condition very much. **(C)** Dorsal view, which enhances the ballooning area where it was patched. Its morphology was eventually satisfactory after a Nesbit procedure was carried out.

Operation for the Venous Patch

A degloving procedure was performed following a circumferential incision in order to expose the deep dorsal vein. The venous trunk (Figure 3A) served as a guide for thorough stripping in which any tributary was double-ligated with 2 ties by using 6-0 nylon sutures before scissors were used to cut them apart. The vein was managed until the level of the infrapubic angle was encountered. During the procedure, it was kept moist with saline instillation. Similarly, a smaller but substantial cavernosal vein was stripped. The deep dorsal vein was spliced side by side when necessary to a length of $2\pi r\theta'/\theta$, where θ' is the incision sector in degrees, θ is the curvature angle, and r is the radius of the penile shaft in erection (Hsu et al, 2006). Similarly, the cavernosal vein was managed if necessary and feasible. Neither a Bovie nor a suction apparatus was applied during the entire procedure. The neurovascular bundle was well protected after hydropressure dissection (Figure 3B) in which normal saline solution was injected into the most curvilinear area between the tunica albuginea and its overlying tissue in order to expand and separate them. A tunical corporotomy was made along the most curvilinear line with the length of $2\pi r\theta'/\theta$. Subsequently, the defect was covered using the transplanted venous wall sutured microscopically to the collagen bundles of the inner circular and outer longitudinal layer of the tunica albuginea with the serosal side outward, using 6-0 nylon sutures (Figure 3C); enhanced sutures were then made 1-cm intervals apart. Two or more corporeal defects were made when the deformity was complex. Finally, the overlying fascia layers and skin were closed layer by layer with 5-0 chromic suture. The operation was performed under local anesthesia on an outpatient basis (Hsu et al, 2003a).

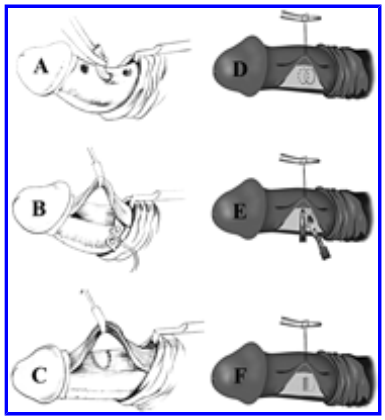

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Figure 3. Schematic illustrations of these techniques. **(A)** In venous patching, a retrocoronal circumferential incision is made and the prepuce is degloved. The major branch of the deep dorsal vein is identified with a milking manipulation. Its trunk serves as a guide to perform the pull-through maneuver of the DDV. The DDV is stripped and double-ligated with each emissary vein and is preserved for patch material. The CV can be managed in a similar manner (not shown). **(B)** The hydropressure technique is used to facilitate the tissue separation, isolation, and tagging of the neurovascular bundle. Subsequently an artificial erection is performed, with normal saline, via a 19 G scalp needle, in order to determine where the depression center of the most curvilinear line is feasible for an incision. **(C)** A corporotomy is made using a new surgical scalpel. The autologous venous grafting with a length of $2\pi r\theta'/\theta$ is continuously fashioned to the tunical defect with its serosal side outward after it is meticulously spliced together, if necessary, using 6-0 nylon sutures. It is reinforced afterwards, intermittently, each 1 cm. **(D)** For the modified Nesbit procedure (secondary curvature correction in this study): After a degloving procedure was performed, the previous patched region was exposed. Long-pronged hemostats were applied to the excessive tunical tissue, including the tunica and previous venous patch for assessing the adequacy of the tunical correction. The suture material left by the previous surgery was intentionally covered. **(E)** A new, sharp surgical scalpel was applied along the prong margin to excise the tissue. Careful compression by an assistant's hand is advisable rather than applying a Bovie to combat the bleeding if encountered. **(F)** A corporotomy defect was fashioned by interrupted 6-0 nylon sutures. The collagen bundle of the outer longitudinal layer was precisely anchored. The overlying Buck fascia was sutured back into place and also preferably Colles fascia.

Secondary Curvature Correction

After the proximal dorsal nerve, peripenile infiltration, and topical injection of the involved tissue were successfully performed, a circumferential incision was made along the previous operative scar. Hydropressure dissection was carried out in which 10 mL of normal saline was delivered in between the Buck fascia and the tunica. Then a degloving procedure was performed to expose the region of the previous graft (Figure 3D). The Buck fascia was meticulously opened. The adequacy of the tunical correction was assessed with long-pronged hemostats applied to the excessive tunical tissue, including the tunica and the previous venous patch (Figure 3E) (Hsu et al, 1997). Using 6-0 nylon suture, the defect was meticulously fashioned (Figure 3F). Subsequently, the overlying Buck fascia, and preferably Colles fascia, was precisely closed with 5-0 chromic sutures, and the skin layer was similarly closed. Neither a Bovie nor a suction apparatus was applied during the entire procedure.

The excised tissues, including the tunica and the venous wall, were collected for microscopic examination (Figure 4). Histologically, hematoxylin and eosin and Masson trichrome stain were used as necessary.

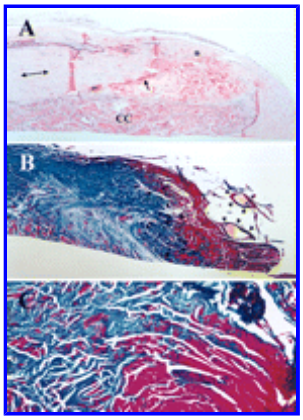

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Figure 4. Histological examination. **(A)** Tissue specimen collected from the patched region of a 31-year-old patient in the congenital group 4 years after the first surgery. The corpus cavernosum (CC) was well covered by the thicker tunica albuginea (double arrows) and a thinner venous graft (asterisk). A 6-0 nylon suture in tangential section (arrow) can clearly be seen. A tissue reaction which is commonly believed to occur with this type of suture cannot be demonstrated despite the magnification power being adjusted upward to search for the characteristic histiocytes (reduced from 40x, hematoxylin and eosin stain). **(B)** Film of the same specimen prepared with Masson trichrome stain for comparison. The collagen bundle (blue color, left) with a wavy appearance had well coalesced (between the arrows) with the smooth muscle fibers (red color, right) which characterize the venous wall. This implies that its original histological character was retained despite its having been transplanted 4 years previously. There was no evidence of a tissue reaction surrounding the 6-0 nylon sutures (arrowheads) (reduced from 40x, Masson trichrome stain). **(C)** The image in panel B was further magnified to study the coalescent healing of the tunica and the donated venous wall. There was no cleft between the collagen bundle (blue color) and the smooth muscle fibers (red color, right) in the entire field (reduced from 400x, Masson trichrome stain).

Cefazolin at 1000 mg intravenously and 80 mg gentamicin intramuscularly were routinely used as prophylactic drugs preoperatively. Cefadroxil monohydrate at 500 mg orally twice daily and 500 mg acetaminophen 4 times daily were prescribed for 1 week, and oral diclofenac 50 mg was taken daily or twice daily postoperatively depending on the perception of pain. All patients were followed up for their satisfaction with the penile morphology with pharmacocavernosography, if necessary, and assessed using the IIEF-5 scoring for erectile capability. Statistically, Student's *t* test and Fisher's exact test were applied when necessary.

Results

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The Table summarizes the general data of these 85 patients. The follow-up period varied from 7 months to 10 years, with an average of 43.8 ± 13.6 months. There was a significant difference in the age distribution and preoperative IIEF-5 scores between the 2 groups ($P < .001$ each).

In the Peyronie group, the mean preoperative erection angle was 52.6 ± 8.7°, which decreased to 7.8 ± 2.3°, while 27 and 18 patients required PGE1-induced erection before and after surgery, respectively. In the congenital group, the mean preoperative erection angle was 41.7 ± 9.3°, which decreased to 4.1 ± 2.1°, while 13 and 7 men required PGE1-induced erection before and after surgery, respectively. Thus the mean angle improvement was 44.8 ± 3.6° and 37.6 ± 3.8° respectively. Overall, the postoperative penile shape was satisfactory in 77 (90.6%) patients, although 3 patients in the Peyronie group and 1 patient in the congenital group complained of shortage (1.5 cm, 1.8 cm, 1.6 cm in the Peyronie group and 1.0 cm in the congenital group) in their postoperative penises. Two patients in the Peyronie group and 1 patient in the congenital group sustained slightly reduced penile sensation. Two patients received a second revision because of an annoying regional ballooning (Figure 3), despite the erectile angle being acceptable. Mild penile deviation of less than 15°, however, was reported in 8 (9.4%) patients. Ten of the 48 patients in the Peyronie group and 5 of 37 patients in the CPD group had undergone previous surgery somewhere else. Overall, 13 patients required 2 (15.3%) patches, and 22 (25.9%) patients required a modified Nesbit procedure in which under-correction was further amended on the contralateral tunica for 19 men and overcorrection was revised in 3 patients in order to attain a satisfactory penile shape.

Slight inflammatory reactions (Figure 4A) were suspected surrounding the 6-0 nylon suture 2 years postoperatively. These had attenuated (Figure 4B), however, in patients who had undergone surgery 4 years previously.

Erectile function has been good in 80 patients, although 6 of them have to use oral sildenafil/tadalafil postoperatively, The mean preoperative IIEF-5 score of 19.7 ± 2.8 increased to a mean postoperative score of 21.6 ± 2.2. This is optimal 1–2 years postoperatively. There was statistical significance between groups either preoperatively or postoperatively ($P < .001$ for both groups). Unfortunately, a satisfactory erection could not be attained for 2 years after the operation in 3 patients who subsequently underwent an Acuform or AMS-650 penile implant.

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In 1992, we explored the 3-dimensional structure of the human tunica albuginea and reported it to be a bilayered structure with multiple sublayers: an inner circular layer and an outer longitudinal layer (Hsu et al, 1992). The outer layer is the tissue which determines the penile shape as well as an essential part for establishing a rigid penis. It is, therefore, crucial to approximate it in any surgical attempt on the tunica albuginea. The recognition of the collagen bundles in the outer longitudinal layer should not be difficult, as their dimensions are consistently larger than those of the inner ones. Their histology is basically the same as the bony structure exclusively noted in lower species of mammals (Hsu et al, 2005). Therefore, it is not surprising that at least half of the patients reported that 6 months is the minimal period for the assessment of functional recovery. This warrants further scientific research.

Assessment of the tunical discrepancy is usually done via a "rule of thumb"; thus, it is an individual surgeon's subjective preference. Recently, however, an engineering formula was developed. Thus, both the dimensions and location of the penile curvature correction can depend on a more scientific formula rather than just relying on the trial and error principle (Hsu et al, 2006). During surgery, it is not difficult to prevent sinusoidal bleeding. Adequate compression to the proximal portion of the tunical defect is delivered by the assistant's hand to prevent bleeding; substantial bleeding, otherwise, may compromise the visibility for the next procedure and, in turn, cause the operation to be aborted. Some surgeons have felt that applying electrocautery directly is very effective to combat a tendency to bleeding, allowing fulguration of the bleeders in this surgery without adverse effects. However, we are very concerned that cautery could lead to clotting of sinusoidal plexuses and intracavernosal fibrosis, resulting in erectile dysfunction (Hsu et al, 2004a).

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*Summary of 85 patients who underwent autologous venous grafting in a recent decade**

Suture material is an important consideration in this surgery. Use of strong nonabsorbable monofilament sutures (eg, 2-0 nylon) is advised for the purpose of curvature correction. We use 6-0 nylon suture for this surgery. Some may be concerned with the tissue reaction from this suture material. In our study, however, the slight foreign-body reaction will attenuate with time, and we

have found no evidence postoperatively of tissue reactions in the tunical specimens of patients who underwent this surgery. This implies that there is little reason for concern.

It is impossible to overstress the importance of avoiding complications in any type of surgery. An operation on the penis, which is extraordinarily delicate, is most challenging. The complications include postoperative shortages, neuropraxia, curvature, lymphedema, infection, misligation of the penile artery, etc (Kim and McVary, 1995; Da Ros et al, 2000). In both groups we had 4 (4.7%) patients who complained of postoperative penile shortage, which must be ascribed to the Nesbit procedure. In both groups we had a total of 3 (3.5%) patients who sustained slight penile numbness, which might be ascribed to nerve injury, misligation, or encasement. These adverse complications appeared to be avoidable, since they did not present in later patients. We attribute this to meticulous use of hydropressure and a learning curve that was steadily gained through this study. We use neither a Bovie nor a suction apparatus in the entire surgery and caution against too much separation of the tissue layers of the penile shaft. We ask an assistant to continually stretch the penile shaft when a repair of the wound is being performed. These annoying complications are preventable, although a study of larger sample size and longer-term observation is mandatory.

The histology of the tunica albuginea is predominantly type I collagen, which establishes its strength. Type III is for an interweaving purpose associated with a few elastic fibers. A strong outer coat is subsequently formed. In contrast, the venous wall is rich in smooth muscle as well as in an elastic component. Theoretically, application of a venous graft may compromise Pascal's principle, since an area of ballooning or weakening may be encountered due to the excessive tensile ability of the grafted venous tissue. In our experience, however, a moderate tension of the grafted vein is deemed to be a prerequisite to prevent this complication if the patched area does not cover the entire circumference. A ballooning or weakened region may otherwise require further revision (Figure 3), similar to our early experience. Repair of the Buck fascia might be helpful in enhancing the force. Interestingly, the grafted venous material consistently retains its histological characteristic of having smooth muscle cells, although perfect coalescence and lining up with the tunica albuginea were unequivocally noted in this study.

An appropriate stripping of the DDV as well as the CV is encouraged, since it may be beneficial to the erectile function according to our long-term observations (Hsu et al, 2004a; Chen et al, 2005; Wen et al, 2005). Similarly, satisfactory postoperative responses are consistently reported in this study. Therefore, the transplanted venous wall may be able to play a proper role in meeting the requirement for establishing a rigid erection if it is precisely fashioned to the tunica albuginea, although a larger sample and a longer period for follow-up are deemed necessary.

In conclusion, the autologous vein appears to be an acceptable graft material, and the transplanted vein may have a modeling action rather than a scaffolding role in autologous venous patch surgery on the penile tunica, since it consistently retains its histological character. Careful microsurgical manipulation is essential to achieve an acceptable outcome, although a larger sample size and longer-term follow-up are necessary.

Acknowledgments

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Alexander W, Carson C. *Rapid Reference to Erectile Dysfunction and Related Disorders*. London: Mosby; 2003 : 16–22.

Bruschini H, Mitre AI. Peyronie disease: surgical treatment with muscular aponeurosis. *Urology*. 1979; 13: 505 –507.[CrossRef][Medline]

Chen SC, Hsieh CH, Hsu GL, Wang CJ, Wen HS, Ling PY, Huang HM, Tseng GF. The progression of the penile vein: could it be recurrent? *J Androl*. 2005;26: 53 –60.[Abstract/Free Full Text]

Collins JP. Experience with lyophilized human dura for treatment of Peyronie disease. *Urology*. 1988; 31: 379 –381.[CrossRef][Medline]

Da Ros CT, Teloken C, Antonini CC, Sogari PR, Souto CA. Long-term results of penile vein ligation for erectile dysfunction due to cavernovenous disease. *Tech Urol*. 2000; 6: 172 –174.[Medline]

Dad S, Amar AD. Peyronie's disease: excision of the plaque and grafting with tunica vaginalis. *Urol Clin N Am*. 1982; 9: 197 –201.[Medline]

Devine CJ Jr, Horton CE. Surgical treatment of Peyronie's disease with a dermal graft. *J Urol*. 1974; 111: 44 –49.[Medline]

Eardley I, Sethia K. *Erectile Dysfunction—Current Investigation and Management*. London: Mosby; 2003: 7 –23.

Fournier GR Jr, Lue TF, Tanagho EA. Peyronie's plaque: surgical treatment with the carbon dioxide laser and a deep dorsal vein patch graft. *J Urol*. 1993;149: 1321 –1325.[Medline]

Gelbard MK, Hayden B. Expanding contractures of the tunica albuginea due to Peyronie's disease with temporalis fascia free grafts. *J Urol*. 1991;145: 772 –776.[Medline]

Gholami SS, Lue TF. Peyronie's disease. *Urol Clin N Am*. 2001;28: 377 –390.[CrossRef][Medline]

Goldstein AM, Padma-Nathan H. The microarchitecture of the intracavernosal smooth muscle and the cavernosal fibrous skeleton. *J Urol*. 1990;144: 1144 –1146.[Medline]

Gray H. Myology: fascia and muscles of the trunk. In: Williams PL, Dyson M, Warwick R, eds. *Gray's Anatomy*. London: Churchill Livingstone; 1989: 587 –608.

Halliday D. Pascal's principle, fluids. In: Halliday D, Resnick R, Walker J, eds. *Fundamentals of Physics.* 5th ed. New York: John Wiley & Sons; 1997: 355 –356.

Hauri D. Penile revascularization surgery in erectile dysfunction. *Andrologia*. 1999; 31(suppl 1): 65 –76.

Hsu GL. Hypothesis of human penile anatomy, erection hemodynamics and their clinical applications. *Asian J Androl*. 2006; 8: 225 –234.[CrossRef][Medline]

Hsu GL, Brock GB, Martinez-Pineiro L, Nunes L, von Heyden B, Lue TF. The three-dimensional structure of the tunica albuginea: anatomical and ultrastructural levels. *Int J Impot Res*. 1992; 4: 117 –129.

Hsu GL, Chen SH, Weng SS. Outpatient surgery for the correction of penile curvature. *Br J Urol*. 1997; 79: 36 –39.[Medline]

Hsu GL, Hsieh CH, Wen HS, Hsieh JT, Chiang HS. Outpatient surgery for penile venous patch with the patient under local anesthesia. *J Androl*. 2003a;24: 35 –39.[Abstract/Free Full Text]

Hsu GL, Hsieh CH, Wen HS, Hsu WL, Chen YC, Chen RM, Chen SC, Hsieh JT. The effect of electrocoagulation on the sinusoids in the human penis. *J Androl*. 2004a; 25: 954 –959. [Abstract/Free Full Text]

Hsu GL, Hsieh CH, Wen HS, Hsu WL, Wu CH, Fong TH, Chen SC, Tseng GF. Anatomy of the human penis: the relationship of the architecture between skeletal and smooth muscles. *J Androl*. 2004b; 25: 426 –431.[Abstract/Free Full Text]

Hsu GL, Hsieh CH, Wen HS, Ling PY, Chen SY, Huang HM, Tseng GF. Formulas for determining the dimensions of venous graft required for penile curvature correction. *Int J Androl*. 2006; 29: 515 –520.[CrossRef][Medline]

Hsu GL, Hsieh CH, Wen YC, Chen SC, Chen SC, Mok MS. Penile venous anatomy: an additional description and its clinical implication. *J Androl*. 2003b;24: 921 –927.[Abstract/Free Full Text]

Hsu GL, Lin CW, Hsieh CH, Hsieh JT, Chen SC, Kuo TF, Ling PY, Huang HM, Wang CJ, Tseng GF. Distal ligament in human glans: a comparative study of penile architecture. *J Androl*. 2005; 26: 624 –628. [Abstract/Free Full Text]

Jordan GH, Schlossberg SM, Devine CJ. Surgery of the penis and urethra. In: Walsh PC, Retik AB, Vaughan ED Jr, Wein AJ, eds. *Campbell's Urology.* 7th ed. Philadelphia, Pa: W. B. Saunders; 1998: 3376 –3386.

Kim ED, McVary KT. Long-term followup of treatment of Peyronie's disease with plaque incision, carbon dioxide laser plaque ablation and placement of a deep dorsal vein patch graft. *J Urol*. 1995; 153: 1843 –1846.[CrossRef][Medline]

Levine PA, Balady GJ, Lazar HL, Belott PH, Roberts AJ. Electrocautery and pacemakers: management of the paced patient subject to electrocautery. *Ann Thorac Surg*. 1986; 41: 313 –317.[Abstract]

Lowe DH, Ho PC, Parsons CL, Schmidt JD. Surgical treatment of Peyronie disease with dacron graft. *Urology*. 1982; 19: 609 –610.[CrossRef][Medline]

Lue TF. Penile venous surgery. *Urol Clin N Am*. 1989;16: 607 –611.[Medline]

Montorsi F, Salonia A, Maga T, Bua L, Guazzoni G, Barbieri L, Barbagli G, Chiesa R, Pizzini G, Rigatti P. Evidence based assessment of long-term results of plaque incision and vein grafting for Peyronie's disease. *J Urol*. 2000;163: 1704 –1708.[CrossRef][Medline]

Moriel EZ, Grinwald A, Rajfer J. Vein grafting of tunical incisions combined with contralateral plication in the treatment of penile curvature. *Urology*. 1994;43: 697 –701.[CrossRef][Medline]

Porena M, Mearini L, Mearini E, Costantini E, Salomone U, Zucchi A. Peyronie's disease: corporoplasty using saphenous vein patch graft. *Urol Int*. 2002;68: 91 –94.[CrossRef][Medline]

Putz R, Pabst R. Pelvic diaphragm [floor]: male and female external genitalia. In: Putz R, Pabst R, eds. *Sobotta Atlas of Human Anatomy.* 13th ed. Philadelphia, Pa: Lippincott Williams & Wilkins; 2001: 222 –239.

Schultheiss D, Lorenz RR, Meister R, Westphal M, Gabouev AI, Mertsching H, Biancosino C, Schlote N, Wefer J, Winkler M, Stief CG, Jonas U. Functional tissue engineering of autologous tunica albuginea: a possible graft for Peyronie's disease surgery. *Eur Urol*. 2004; 45: 781 –786.[CrossRef][Medline]

Schwarzer JU, Muhlen B, Schukai O. Penile corporoplasty using tunica albuginea free graft from proximal corpus cavernosum: a new technique for treatment of penile curvature in Peyronie's disease. *Eur Urol*. 2003;44: 720 –723.[CrossRef][Medline]

Tudoriu T, Bourmer H. The hemodynamics of erection at the level of the penis and its local deterioration. *J Urol*. 1983; 129: 741 –745.[Medline]

Wen HS, Hsieh CH, Hsu GL, Kao YC, Ling PY, Huang HM, Wang CJ, Einhorn EF. The synergism of penile venous surgery and oral sildenafil in treating patients with erectile dysfunction. *Int J Androl*. 2005;28: 297 –303.[CrossRef][Medline]

Wespes E, Nogueira MC, Herbaut AG, Caufriez M, Schulman CC. Role of the bulbocavernosus muscles on the mechanism of human erection. *Eur Urol*. 1990;18: 45 –48.[Medline]