DOI: 10.34057/PPj.2020.39.02.003
Pelviperineology 2020;39(2):42-49

Tethered vagina syndrome

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ABSTRACT

The key to understanding the pathogenesis leading to the "Tethered vagina syndrome" and its cure by a skin graft applied to the anterior vaginal wall is to understand the importance of the three oppositely-acting directional forces which close the urethral tube and on relaxation of the forward force, open it for micturition. Any scarring from vaginal excision during "native tissue repair", application of large mesh sheets, or overstretching by a Burch colposuspension effectively "tethers" the more powerful posterior forces to the weaker anterior force; the posterior urethral wall is pulled open exactly as happens during micturition; the patient loses urine uncontrollably typically on getting out of bed in the morning, which is the classical diagnostic symptom.

INTRODUCTION

The "Tethered vagina syndrome (TVS)" is an iatrogenic, but as yet, not well recognised condition. It is caused by scar-induced tightness in the middle zone of the vagina (Figure 1a, b). This syndrome assumes a special position in the concept of the integral theory. Whilst all other bladder symptoms are mainly caused by lax connective tissue, the massive functional problem of the TVS is generated by rigid connective tissue structures.

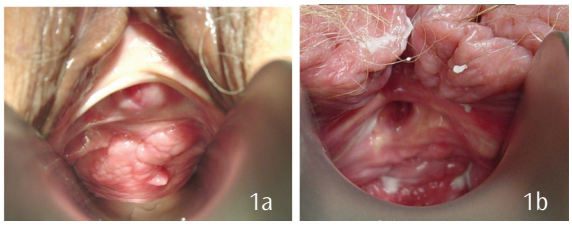

Figure 1a and b. Thick scar tissue in the bladder neck area of vagina; typical for the "tethered vagina syndrome"

The TVS was described by Petros and Ulmsten in 1990, and again in 1993.[1-3] It is not defined as a separate entity by the International Continence Society.[4] This problem is somewhat similar to "motor detrusor instability", and may arise in patients with multiple previous operations in the bladder neck area of vagina. In contrast to that the classical tethered vagina symptom is commencement of uncontrolled urine leakage as soon as the patient's foot touches the floor, indeed, often commencing as the patient rolls over to get out of bed in the morning. The patient does not complain of bed-wetting during the night. The symptoms are caused by loss of elasticity in the bladder neck area of the vagina: the so-called "zone of critical elasticity" (ZCE) (Figure 2). Scar tissue in this area (Figure 3) blocks the physiological opening and closure mechanism, because this mechanism is mainly controlled by the pubo-urethral ligament (PUL) (green arrow in Figure 4a) and not by a so-called sphincter

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Received: 10 December 2019 **Accepted:** 10 January 2020

in the bladder neck area (black arrow in Figure 4a). Operations in the bladder neck area lead to unphysiological results and functions (Figure 4b, c, Figure 5).

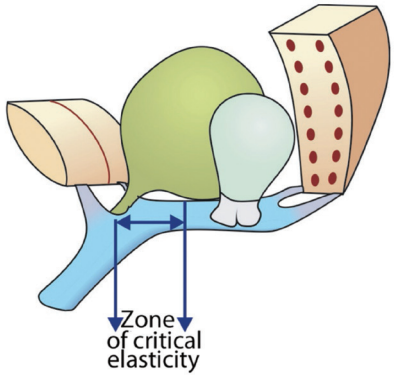


Figure 2. Zone of critical elasticity

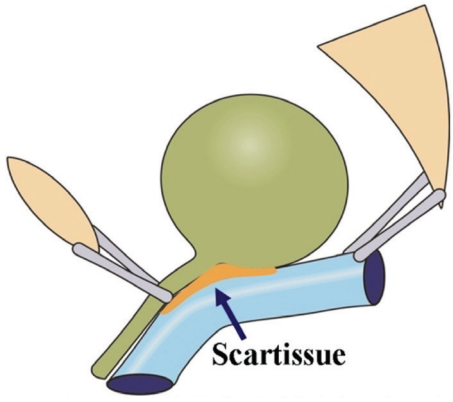


Figure 3. Scar tissue blocks the physiological opening and closure mechanism

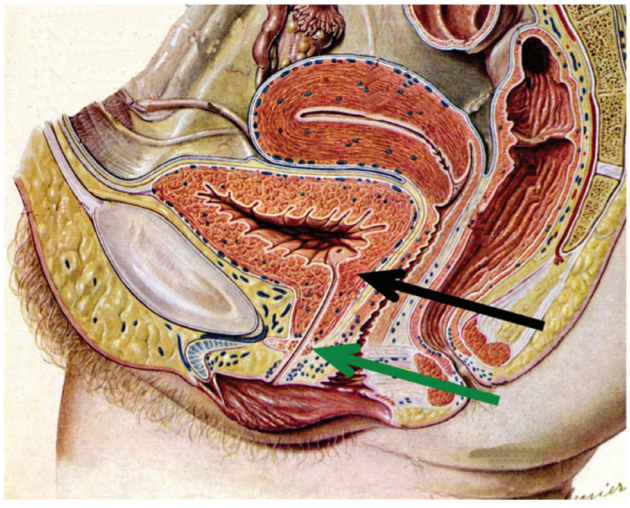


Figure 4a. The opening and closure mechanism are mainly located in the area of the [PUL (green arrow) and not in the sphincter area (black arrow)]
PUL: Pubourethral ligament

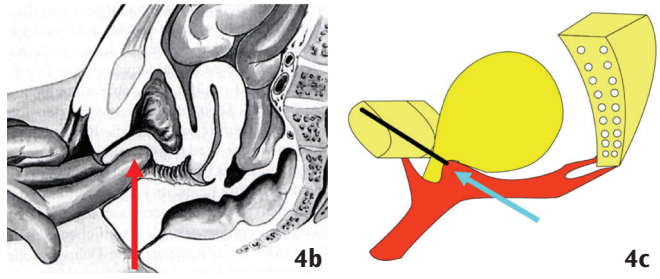


Figure 4b and c. Operations in the bladder neck area lead to the unphysiological results and functions

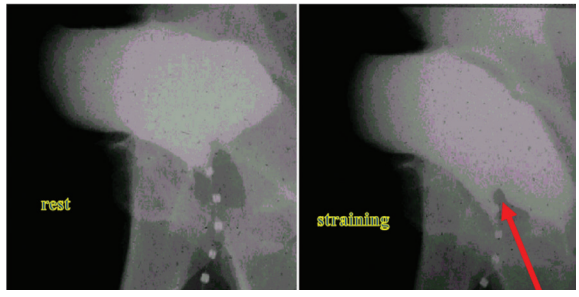


Figure 5. Lateral cystogram after Burch-colposuspension show the unphysiological elevated bladder neck (red arrow) during strain

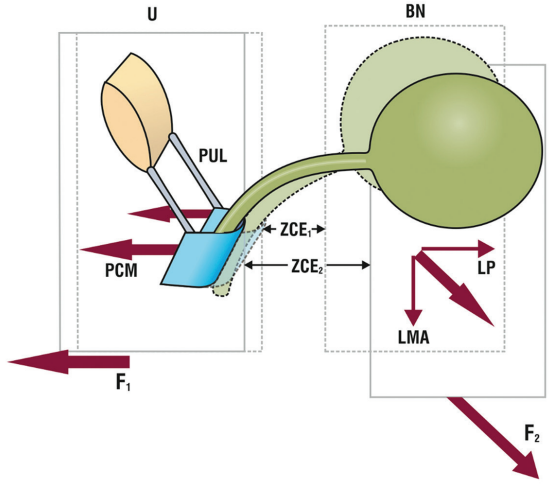


Figure 6. The Zone of critical elasticity (ZCE) ZCE1=ZCE at rest; ZCE2=ZCE during effort or micturition. Adequate vaginal elasticity at ZCE allows the oppositely acting urethral) (U) and bladder neck (BN) closure mechanisms to operate. F1 represents the forward acting vector, which stretches the vaginal hammock forwards to close the distal urethra (urethral closure mechanism). F2 stretches the proximal urethra backwards and downwards against the pubourethral ligament "PUL", to close it (bladder neck closure mechanism). A scar at ZCE "tethers" the oppositely acting muscle vector forces, so that on application of a strong prolonged force, such as occurs on getting up out of bed in the morning, F2 overcomes F1, and the posterior wall of the urethra is pulled open, exactly as occurs during micturition.
PCM: Pubococcygeus; LP: Levator plate; LMA: Longitudinal muscle of the anus. F2 represents the resultant force of the LP/LMA vectors, U: Urethral, BN: Bladder neck, PUL: Pubourethral ligament, ZCE: Zone of critical elasticity

Figure 6 illustrates why elasticity at ZCE is necessary for the separate function of urethral (U) and bladder neck (BN) closure mechanisms. ZCE stretches from mid-urethra to bladder base. Scarring across ZCE "tethers" muscle vectors F1 and F2. Then F2 overcomes F1 to pull open the vaginal hammock on effort, causing uncontrolled urine loss.

SYMPTOMS

Because scar tissue contracts with time, the TVS may present many years after vaginal repair or bladder neck elevation. Patients with exclusively TVS do not wetting the bed and do not suffer from urge. Furthermore, often there is no or only very little stress incontinence. The reason is that cough creates short sharp fast-twitch contractions, and there may be just sufficient elasticity at ZCE to prevent urine leakage on coughing. However, if the vagina just behind the scar is gently stretched backwards by Allis forceps, all the residual elasticity is removed from ZCE, and urine is now lost on coughing. However, isolated tethered vagina symptomatology is rare. In most cases the rigid anterior vaginal wall generates a redistribution of pressure to the posterior vagina resulting in a recto/enterocele. This happened in 96% of our cases (see below chapter: Results). A temporary stiffness in ZCE sometimes occurs after insertion of a sub-urethral sling resulting in de novo urine loss after getting out of bed. In most cases elasticity slowly comes back during the following weeks and month due to decreasing tissue tension in the scar area. This improves the incontinence symptomatology without any treatment. The explanation for urine loss due to scar tissue in ZCE is as follows: Getting out of bed stretches ZCE far more than cough, as the pelvic floor has to contract powerful in order to support all the intra-abdominal organs. Thereby the outflow tract is opened abruptly with the result of massive uncontrolled urine loss as soon as the patient's foot touches the floor. In case of scar tissue in ZCE the bladder neck is porcelain-like and acts like a watering can in the following sense: In supine position bladder fills (Figure 7a). If the patient starts to get up in the sitting position, the levator plate contracts. Scar tissue blocks the effect of the pubococcygeus muscle resulting in an open outflow tract as usual during micturition (Figure 7b). From sitting to vertical position urine leaking starts, whereas in standing position the urine loss is massive (Figure 7c). Reaching the toilet, the bladder is almost empty (Figure 7d).

Vaginal examination

Usually it is no problem to see and feel the scarred bladder neck area whilst speculum and vaginal examination. Nevertheless, it is very important for therapy to clarify whether the scar is responsible for incontinence or not. Stress and urge incontinence require a totally different operation than tethered vagina. As already mentioned above cough and strain do not lead to urine leakage in typical tethered vagina patients. However, if the vagina just behind the scar is gently stretched backwards by Allis forceps, all the residual elasticity is removed from ZCE, and urine is now lost on coughing.

There are three types of tethered vagina patients:

1) Patients after traditional incontinence surgery, such as;

a) Anterior Colporrhaphy,

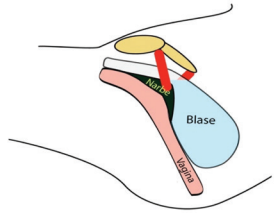


Figure 7a. Bladder fills in supine position

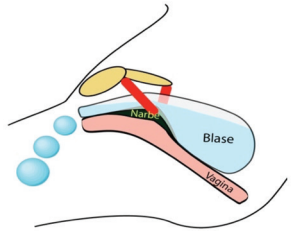


Figure 7b. Getting up: scar prevents urethral closing

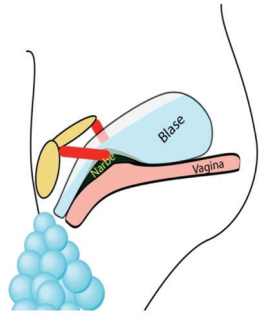


Figure 7c. Foot on the floor: massive urine loss

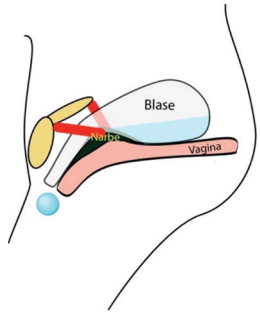


Figure 7d. Reaching the toilet: bladder is almost empty

b) Cystourethropexy according to Marshall-Marchetti-Krantz,

c) Colposuspension described by Burch,

d) Urethral bulking operations with Teflon, Macroplastique etc.

These patients show a very tight anterior vaginal wall with thick scarring (Figure 8) or excessive elevation (Figure 9).

2) Patients after sling procedures with autologous or artificial material, such as;

a) Narik-Palmrich inguino-vaginal sling operation

b) STRATASIS™ Urethral sling

c) Wrong placed sling or mesh crossing the bladder neck area This type of patients show a more restiform, rope shaped scar area (Figure 10), sometimes with protrusion of tape or mesh (Figure 16,17. See below).

3) Patients with vesico-vaginal fistula

In poor countries at least 3 million women have unrepaired vesicovaginal fistulas (Figure 11). 30,000-130,000 new cases develop each year solely in Africa.[5] Success rates of closure for primary surgery range from 73% to 90%.[6] Nevertheless, only 16 to 55% of the patients are continent after closure of the fistula.

Figure 8. Thick scar tissue in the urethral and bladder neck area

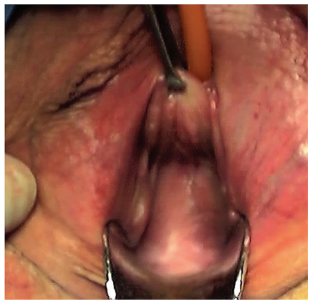


Figure 9. Excessive elevation of bladder neck after eight operations in this area

In nearly all cases the reason for that is scar tissue formation causing the TVS. Petros et al.[7] observed only in two of 95 cases hypermobility in the bladder neck area after fistula repair during ultrasound examination. All other patients demonstrated a rigid zone of critical elasticity.

DIAGNOSTIC

Ultrasound

The typical finding on ultrasound is no significant movement,

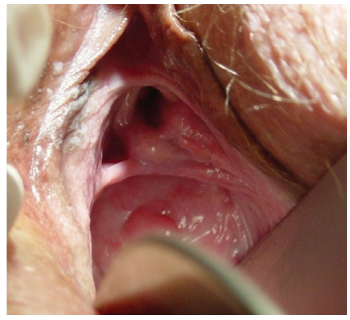


Figure 10. Restiform, rope shaped scar area

funnelling or opening out of bladder neck during straining or squeezing (Figure 12 a, b; Figure 13 a, b).

Urodynamic

Urodynamic usually demonstrates no significant pattern as fluid flow back from the bladder through the rigid urethra like through a “watering can”. One typical urodynamic finding can be a low urethra pressure profile due to rigid tissue (Figure 14).

Therapy

Periurethral application of micro-balloons in the bladder

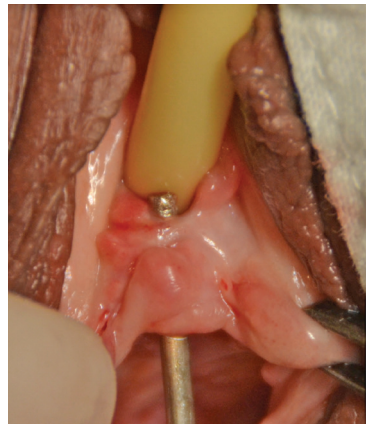


Figure 11. Scar tissue and vesico-vaginal fistula due to three previous bladder neck operations cured by closure of the leak and a Martius skin on flap

neck area definitely does not make sense, as this area is already rigid. This procedure will worsen the situation again. Artificial sphincter implantation is a very expensive and extremely invasive therapy with numerous side effects.

Therefore, our strategy consist of two parts:

1) Removal of all scar tissue and artificial material.

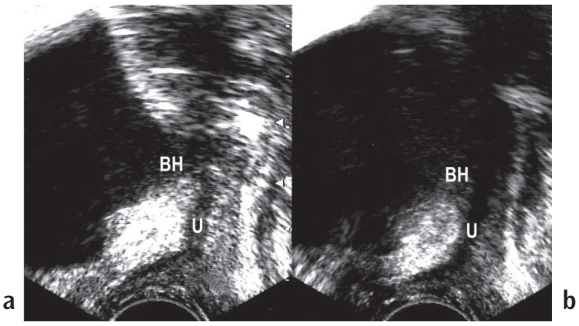


Figure 12 a **and b.** Patient with eight previous operations in the bladder neck area. The BH in rest (left) is extremely elevated up and back through which the posterior wall of the bladder slipped down. During squeezing (right) the bladder neck stays in this position, whereas the posterior wall of the bladder moved in the normal position
BH: Bladder neck, U: Urethra

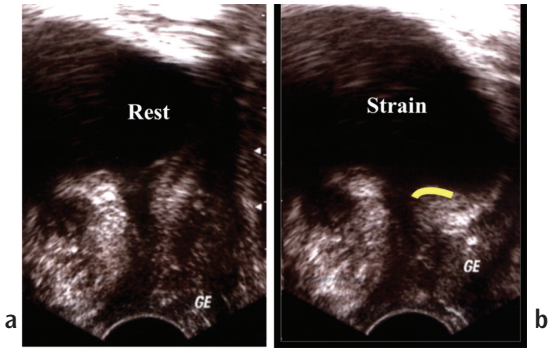


Figure 13 a and b. Patient with three previous bladder neck operations: (**a**) rest, (**b**) no movement of bladder neck area during cough or strai

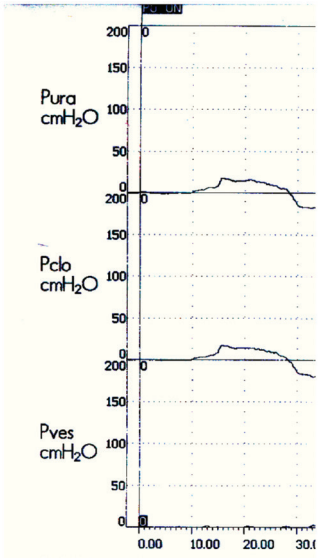


Figure 14. Urethral pressure profile from patient Figure12 with tethered vagina.
Low urethra pressure due to the scar-induced tightness of the urethra

2) Restoration of the elasticity in the neck area of the vagina, the "zone of critical elasticity" (ZCE), so that "F1" and "F2" can act independently of each other (Figure 6).

1) Removal of scar tissue and artificial material

The anatomical basis of our operation resides in the Integral Theory,[8,9] which states that adequate elasticity is required in the bladder neck area of the vagina so as to allow the opposite muscle forces to operate independently of each other (Figure 6). Whatever the technique used to restore elasticity, it is essential to dissect the vagina from the bladder neck and urethra, and then to free all scar tissue and artificial material from urethra, bladder neck (urethro-vesicolysis) and pubic bones (Figure 15 a, b; Figure 16 a, b; Figure 17).

2) Restoration of the elasticity neck area of the vagina, the "zone of critical elasticity" (ZCE)

A simple closure of the incision after scar dissection will create new scar tissue with recurring incontinence. In order to prevent scarring again, healthy tissue has to be brought in the ZCE. Since 1999 we tested the validity of three different operations, all of which aim to restore elasticity in the bladder neck area of the vagina.[10,11]

The I-plasty-operation: (Figure 18) was performed in 13 patients with a co-existing cystocele. I-plasty aims to increase the volume of tissue in the bladder neck area of the vagina, thereby restoring elasticity. To reach this aim a vertical full thickness incision was made from mid-urethra to at least 3-4

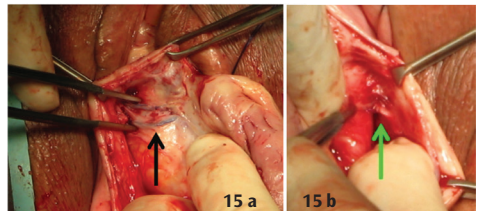


Figure 15. Tethered vagina due to Burch Colposuspension (**a**) (left). Due to Urethro-vesical suspension (Stamey Pereyra) (**b**) (right). The Vagina is dissected from the bladder and proximal urethra. The Burch sutures (black arrow left picture and the Stamey Pereyra suture (green arrow right picture)

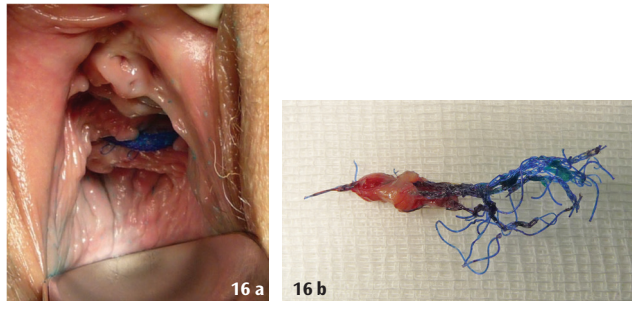
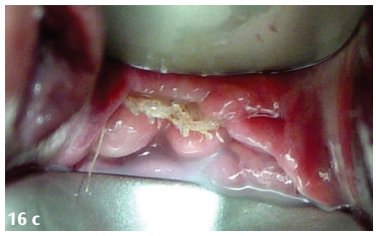


Figure 16 a and b. Patients with tethered vagina syndrome due to sub-urethral sling erosion before (**a,c**) (left) and after (**b,d**) (right) removal



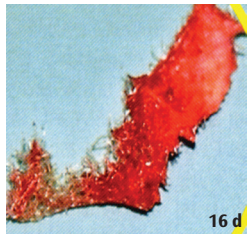


Figure 17 a and b. Tethered vagina due to erosion before **(a)** (left) after **(b)** (right) mesh insertion. Mesh extended from urethra to cervix cm beyond bladder neck. The vaginal skin was dissected off the scar tissue and was extensively mobilised, forwards to the edges of the vaginal hammock, backwards as far possible right down to the hysterectomy scar, and as laterally as possible. The freed tissue was brought into the ZCE and sutured transversely with interrupted sutures.

The skin graft operation: (Figure 19) was performed in 21 Patients. After a full thickness transverse incision in the area of bladder neck the vagina, urethra and bladder neck were freed from the scar tissue. This resulted in opening up of a large gap. Care was taken to effect haemostasis. A full thickness skin graft approximately 6x4 cm was taken from the lower abdominal wall. After removal of underlying-fat the graft was applied to the bladder base using several "quilting sutures". The graft was then trimmed as necessary, and sutured to the adjacent vaginal skin with interrupted 00 Vicryl.

Bulbocavernosus-skin-fat-flap with vessel pedicle (according to Goeschen) or Martius-skin-on-flap (Figure 20 a-f) In 105 patients the large gap after scar dissection was covered with a bulbocavernosus-muscle-fat-skin-flap from the labium majus. A 5x3 cm ellipse of vulval skin was created over the labium majus and transferred with underlying fat and muscle through a tunnel into the dissected area. The tunnel must be sufficiently large to avoid constriction of the vascular pedicle. The graft was attached to the adjacent vaginal skin.

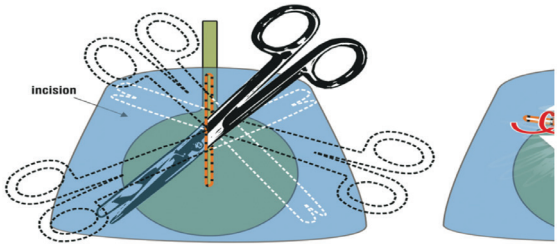


Figure 18. I-plasty operation; A vertical incision is made in the bladder neck area of vagina. The vagina and urethra are extensively mobilized off the adjoining tissues and pelvic sidewall. The incision is sutured horizontally, thus introducing fresh tissue to the site

RESULTS

The cure rates (urine loss <10 gm during 24 hours) were, for I-plasty 3/13 (23%), for the skin graft 11/21 (52%) for the bulbocavernosus-flap and 84/105 (80%). The mean operating time was 62 minutes (range: 41-98 min). Exclusively a tethered vagina repair was performed in five patients, and in 134 cases, a concomitant entero/rectocele repair was necessary at the same time. No serious bleeding was observed. The mean hospital stay was 5 days (range 2-9 days). All patients were mobile at least 4 hours after the operation. Three patients could not pass urine after removal of the catheter one day after the operation and further permanent catheter was

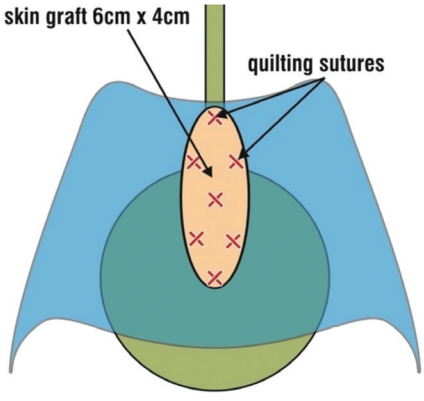


Figure 19. Skin graft to bladder neck area of vagina is attached by quilting sutures

Figure 20 a. 5x3 cm ellipse of vulval skin is marked over the labium majus

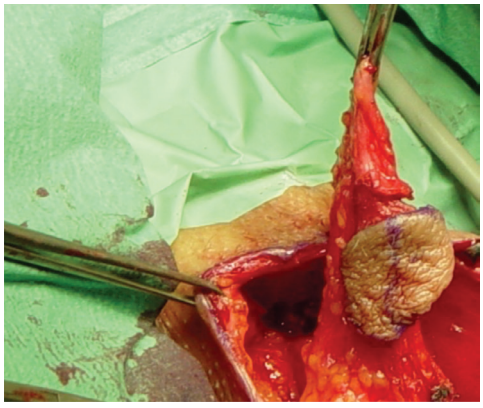


Figure 20 b. Preparation of a bulbocavernosus-muscle-fat-skin-flap with vascular pedicle

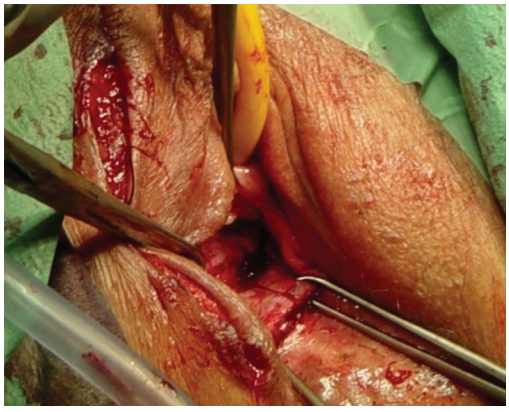


Figure 20 c. Transverse incision at bladder neck. Vagina, urethra and bladder neck are freed from the scar tissue

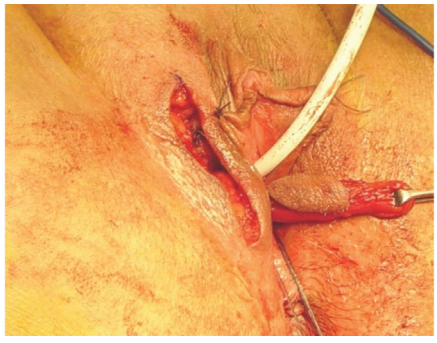


Figure 20 d. The graft is brought through a tunnel in the lateral vaginal sulcus into the dissected area

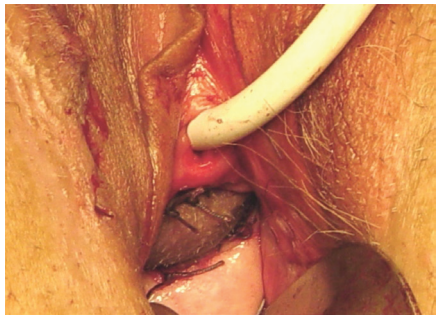


Figure 20 e. The graft is attached to the adjacent vaginal skin

Figure 20 f. Flap after 3 months

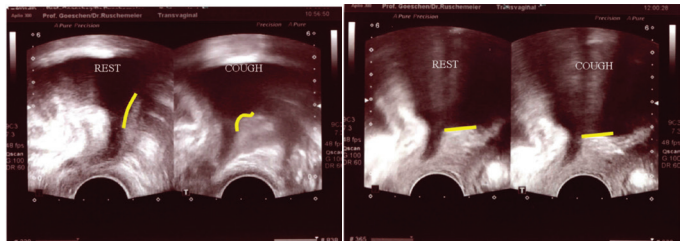


Figure 21 a, b. Ultrasound findings before (left) and after (right) restoration of laxity.
(**a**) Before operation: no movement of bladder neck area during cough or strain
(**b**) After operation: normal movement of the bladder neck area

necessary for another 1 day.

Ultrasound control after bulbocavernosus flap

Ultrasound in successful operated cases shows a normal movement in the bladder neck area and ZCE (Figure 21).

CONCLUSION

Regarding cure of tethered vagina the aim must be to restore the elasticity in the bladder neck area of the vagina, the "zone of critical elasticity" (ZCE), so that "F1" and "F2" can act independently of each other (Figure 6). As a first step, it is essential to dissect the vagina from the bladder neck and urethra, and to free all scar tissue from urethra, bladder neck and pubic bones (urethro-vesicolysis). There must be no scar tissue anchoring the bladder neck to the pelvic sidewall. The second step is to bring fresh tissue to the bladder neck area of the vagina to restore elasticity, and prevent new scar creation in this area. The **I-plasty operation** cures less than one fourth of the patients. Therefore, we decided not to continue with this method in cases where there is obvious tissue deficit. It is still the simplest technique but only indicated if there is no tissue deficit. The I-plasty works very well in patients where the cause is excessive bladder neck elevation, for example, after a Burch colposuspension and with a co-existing cystocoele.

If there is a severe shortage of tissue or a large gap after dissection, this defect has to be covered with a skin graft or a flap. The results with **free skin graft** are much better than with I-plasty, but a cure rate of about 50% is still not convincing. A free graft is problematical because there is no blood supply. Therefore, up to one third may not "take", or the graft may shrink excessively. The **bulbocavernosus-flap operation** is technically more challenging, but brings its own blood supply. This is in our opinion the explanation for the high cure rate. Using this technique, it is very important not to compromise the blood supply of the graft. Therefore the pedicle must be thick enough to prevent too much compression to the vessels in the pedicle, and the space created in the lateral vaginal wall for passage of the graft must be adequate. The explanation for cure of TVS by restoration of elasticity in this area may be explained by reference to a previously described hypothesis,[8,9] (Figure 6): there are separate urethral and bladder neck closure mechanisms. In the former, forward vectors stretch the underlying vagina on each side to close the urethra from behind. In the latter, backward/downward vectors stretch the proximal vagina and bladder base backwards and downwards to close off the bladder neck. Adequate elasticity is required for these separate movements. If fibrosis occurs at this critical point then the opportunity for independent movement is lost and the stronger posterior force overcomes the weaker anterior force. As a result, the urethra is forced open.

ETHICS

Ethics Committee Approval: Since this article is actually a review article for the Pelviperineology as a teaching module; It does not require ethics committee approval.

Peer-review: Externally peer-reviewed.

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