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Efficacy of Three Corporotomies to Correct Ventral Penile Curvature. Experience in 400 Patients with Severe Hypospadias

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ABSTRACT

Purpose: We determined the efficacy of 3 corporotomies to straighten ventral curvature (VC) measuring 30- 130° during the first stage of a 3-stage STAC repair in boys with proximal hypospadias, confirmed by artificial erection (AE) at the subsequent stages.

Methods: Consecutive Tanner 1 males with proximal hypospadias and VC 30° or more underwent primary or reoperative STAC repair. Straightening was done by 3 ventral corporotomies during STAC 1, with AE repeated during STAC 2 and 3, and any reoperations for complications. The primary outcome was any ventral curvature and/or bleeding complications defined by intervention on the Clavien Dindo scale.

Results: There were 131 primary and 70 reoperative STAC repairs done between 20019 and 2021. VC averaged 66°, with 22% measuring 90°-130°. An average of 2.3 AEs were done after straightening, with the last one 12 or more months later (mean 21). 86% had no VC. Residual VC in the remainder was most likely in those with 90° or more VC initially, and was successfully corrected with a single Heineke-Mikulicz dorsal plication using 4-0 polypropylene in most. Therefore, 98% of patients were proven to have successful straightening. There were no bleeding complications.

Conclusions: 3 corporotomies alone were successful in 86%, which increased to 98% with a subsequent dorsal plication in those with residual VC. The fact that residual curvature occurs, especially in those with VC 90° or more, emphasizes need for AE to be repeated at the next operation in staged repairs.

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ABSTRACT

Purpose: We determined the efficacy of 3 corporotomies to straighten ventral curvature (VC) measuring 30-135° during the first stage of a 3-stage STAC repair in patients with proximal hypospadias, as confirmed by artificial erection (AE) at STAC 2 and STAC 3.

Methods: Consecutive males with proximal hypospadias and VC 30° or more underwent primary or reoperative STAC repair. Straightening was done by 3 ventral corporotomies during STAC 1, with AE repeated during STAC 2 and 3, and any reoperations after STAC repair for complications. Residual VC at STAC 2 was straightened by 1 Heineke-Mikulicz dorsal plication. The primary outcome was any ventral curvature. Secondary outcomes included bleeding complications requiring intraoperative or postoperative intervention, and reported change in erection quality in Tanner 4,5 patients.

Results: There were 237 primary and 163 reoperative STAC repairs done between 2019 and 2024. VC averaged 74° (**median 75°)** in primary cases, with 85% having more than 30-45° and 1 in 4 more than 90°. VC in reoperations was less ($p<0.00001$), averaging 54° (**median 50°).** All patients had at least 2 AE after corporotomies, with the final an average of 17 (11.5-58) months later. 81% had no VC at STAC 2. Residual VC in the remainder was always 30° or less, was more common in those with >90° initially ($p<0.00001$), and was successfully corrected with a single Heineke-Mikulicz dorsal plication in most. Therefore, 99% of patients were proven by AE to have successful straightening. There were no bleeding complications requiring intervention. One adult reported 15% decrease in erection fullness.

Conclusions: 3 corporotomies alone were successful in 81%, which increased to 99% with a subsequent dorsal plication in those with residual VC. The fact that residual curvature occurs after all straightening methods, including 3 corporotomies, emphasizes need for AE to be repeated at the next operation in staged repairs and during reoperations.

KEYWORDS: Proximal hypospadias, ventral penile curvature, penile corporotomies, STAC repair

INTRODUCTION

Straightening VC is the foundation for successful proximal hypospadias repair. Persistent VC is associated with increased likelihood for urethroplasty complications (1), and, even if the neourethra heals without those, VC of only 20º can cause sexual dysfunction and related mental stress in men (2).

However, this step is challenging, given that the curvature in primary proximal hypospadias averages 70º and can range to as much as 135º (3). Furthermore, there is no consensus regarding the best method for straightening, with surgeons using chordee excision, dorsal plication, or ventral lengthening. In addition, although failed straightening can be diagnosed within 6 months of surgery (1), it is often overlooked in infants and boys because parents are unsure of what they have observed, erections may not occur during postoperative clinic assessments, and there may be a low index of suspicion by surgeons, who do not repeat AE at subsequent operations.

We straightened VC using 3 corporotomies during the initial operation of a 3-stage STraighten And Close (STAC) repair (4), and then repeated artificial erection (AE) at each subsequent

stage and during reoperations for complications to determine if the curvature was successfully corrected. Results in consecutive patients are now reported.

METHODS

After degloving, AE was done using a 23 or 21 gauge needle in infants/toddlers and boys, respectively, and 18 gauge needle in Tanner 4 or 5 teens and adults to create a fully erect penis. Curvature was measured by goniometry with the fulcrum placed at the point of greatest curvature and the distal arm at the correct meatal location (5). Consecutive patients with 30º or more VC underwent primary or reoperative STAC repair and comprised the study cohort reviewed with IRB approval.

After determining the extent of VC, the urethral plate was transected at the corona and then dissected in continuity with the urethra off the corpora to within the scrotum. AE was repeated and a transverse line drawn from 3 to 9 o'clock at the point of greatest bending. A second and third lines were similarly marked approximately 4 millimeters distal and proximal to the first. With a tourniquet in place and the assistant holding the surface taut, incisions were made along each line extending just through the tunica albuginea to expose the erectile tissues

without incising into them (Video, Figure 1).

Next, a rectangular dartos flap was raised from adjacent shaft skin and laid over the 3 incisions, covering them completely. This was secured to the tunica albuginea around the perimeter just outside of the incisions using closely placed, interrupted, horizontal mattress sutures of 6-0 polydioxanone (5-0 in adults) to prevent blood leakage when the tourniquet was released. 3 additional sutures were placed in the middle and laterally along each of the isthmuses between incisions to further help contain bleeding (Figure 1).

1:1000 epinephrine was drizzled over the dartos and then the assistant compressed the area with a gauze pad while the tourniquet was released. Meanwhile, the urethra/urethral plate was gently stretched back distally and stitched along the midline to the corpora. The distal end of the plate was secured where it reached without tension, usually just below the proximal incision or to the isthmus between it and the middle incision (Figure 1). Any bleeding from around the edges of the dartos flap was stopped with additional interrupted stitches.

At the conclusion of STAC 1, a petroleum gauze was placed and then a Coban™ elastic bandage was wrapped around the penis,

ensuring it was not tight. Next, Tegaderm™ was secured around the base of the bandage and to the penopubic and penoscrotal skin in order to prevent its upward displacement in the early postop period. These dressings fell off spontaneously within 5-7 days and were not replaced. A catheter provided urinary diversion for 1 week.

Six or more months later, AE was repeated after degloving at STAC 2, and then again after at least another 6 months during STAC 3. AE was also done during any reoperations after STAC 3 for urethroplasty complications, such as fistula or glans dehiscence repair.

When residual bending was found, 2 forceps were used with the penis fully erect to mimic dorsal plication and estimate the force needed for straightening. When little or no resistance was encountered, a Heineke-Mikulicz dorsal plication was done, making a 2mm puncture into the corpora in the dorsal midline opposite the bending and placing a single 4-0 polypropylene suture, burying the knot. Repeat AE confirmed straightening after the plication.

The primary outcome was any degree of VC after straightening. The secondary outcome was bleeding complications, defined

as bleeding requiring intervention such as re bandaging, return to surgery, blood transfusion, or evaluation by an emergency department. Tanner 4 and 5 patients were systematically questioned regarding a change in quality of erection during postoperative assessments, comprising the tertiary outcome.

Statistical analysis was done with Mann Whitney U and Chi square analysis (www.graphpad.com, 2025).

RESULTS

A total of 400 patients underwent STAC between 2019 and 2024, comprising 237 primary repairs and 163 reoperations of patients originally operated elsewhere. Demographics and results are shown in the Table. VC averaged 66º (30-135**) (median 65 º, IQR 45-80**), and was greater in primary than reoperative patients (77.7° SD 23.7 vs 53.6° SD 17.1, $p<0.00001$). VC was greater than 30-45° in over 85% of primary patients, of which 1 in every 4 measured more than 90°.

All patients had at least 2 AEs after straightening (mean 2.4, 2-5) with the final one done in all cases more than 11.5 months after initial correction (average 17 months). VC was found by AE

during STAC 2 in 76 patients (19%) (Figure 2), all measuring 30º or less (mean 22.4, 10-30). This was more likely as the degree of initial curvature increased, and occurred in 43% whose original VC was 91° or greater ($p<0.00001$). A single Heineke Mikulicz dorsal plication corrected the residual bend in all but 5 of these, who had curvature at STAC 3 that measured 30° in 1 and 15° in the others. Therefore, successful curvature correction was documented by AE in 99% of cases. Most Tanner 2-4 patients had a negative AE at STAC 2, and none had recurrent curvature at STAC 3 despite their continuing pubertal growth.

A small bulge in a corporotomy was imbricated in 2 patients (0.5%) at stage 2 without recurrence. There were no bleeding complications intraoperatively, and no patient required postoperative rebandaging of the elastic wrap, return to the operating room, blood transfusion, or emergency department evaluation.

One adult reported an approximately 15% decrease in the fullness of his erections after STAC 1 that remained unchanged at 1 year follow up and was managed with tadalafil. No other patient reported a decrease in erection quality. Representative postoperative photos of erections after 3 corporotomies are

shown in Figure 3.

DISCUSSION

This study makes several important observations. First, systematic AE during STAC 2 objectively demonstrated the results of 3 corporotomies to correct VC at STAC 1. Corporotomies alone were successful in 81% despite VC averaging 66° and ranging to 135°. Residual curvature in the others was 30° or less and occurred most often in patients whose original bend was more than 90°. A single dorsal plication resolved the remaining curvature in nearly all of these, as confirmed by another AE during STAC 3. Altogether, we documented successful penile straightening in 99% of these patients. The 5 with persistent VC at STAC 3 underwent a second plication, but were considered by the study design to have failed straightening since no additional AEs were done.

Corporotomy incisions made across the arc of curvature release tension and lengthen the shorter ventral side of the tunica albuginea so that the corpora can extend straight during erections. The residual VC that occurred most often in those with the greatest bending could have resulted from inadequate

incision to completely release tension and lengthen the ventral surface, or from partial or complete closure of 1 or more of the incisions. Regardless, this curvature was always less than 30º and the dorsal plication we mimicked using forceps during full erection met little resistance. This same test performed before corporotomies typically finds much greater tension that is difficult or impossible to overcome to pull the penis straight when VC is 30° or more.

The technique for 3 corporotomy incisions is the same as we first described in 2009 (6), extending completely through the tunica albuginea but not into the erectile tissue. Originally the incisions were covered by the urethroplasty graft as part of a 2-stage STAG repair. Being unable to confirm the penis was straight, we also placed a single Baskin dorsal plication at that time. STAC delays urethral grafting to STAC 2, and so a dartos flap is now laid over the incisions during STAC 1 to prevent penile skin from adhering to them. We also stopped dorsal plications during the first stage, reserving them for the minority who have residual bending at STAC 2.

This study was undertaken to objectively document the success of straightening relying on AE, rather than reports by caregivers or

postoperative examinations with finger compression which might not reliably detect residual VC. Since persistent or recurrent VC has been diagnosed within 6-12 months of straightening (1,7), our follow-up a minimum of 11.5 and mean of 17 months was considered sufficient to determine early outcomes and is similar to that of the other few series which also used AE to document results from 8 to 38 months postoperatively (8-10).

Nevertheless, there could be concern for recurrent VC during pubertal growth. That was not observed in our Tanner 2-4 patients in active puberty, and has not been commonly reported by others. 4 studies we found all described assessment after puberty in patients whose original curvature correction was by skin release/chordee excision, or dorsal plication, (11-14) which are not reliable for straightening VC 30° or more (1,15,16). Therefore, the bending these authors observed at puberty was quite likely persistent since childhood rather than newly developed from pubertal growth. In contrast, we previously described findings in a series of teens and adults with complications after childhood repair and reported that all recurrent VC developed before puberty (17). In fact, we have not yet encountered a teen or adult who reported his penis was straight before puberty and then

began bending.

Because AE cannot be done during the same procedure, surgeons first using 3 corporotomies sometimes ask how to be certain they have straightened the curvature. We described intraoperative measurements that can be done (18), but have not used those for several years. Rather, we observed that the same corporotomy incisions widen to varying degrees according to the severity of bending, and our study proves the 3 corporotomies alone or with a subsequent dorsal plication successfully straighten nearly all VC. Surgeons performing this procedure as we have described should achieve the same results.

It has been suggested that more superficial corporotomy incisions not exposing the erectile tissues might be equally effective and allow simultaneous AE. To our knowledge, results of this method have not been reported, and we are concerned that failure to incise through the tunica albuginea might result in inadequate incision and persistent VC as we have seen in some reoperative patients whose original operative dictations report 'superficial' corporotomies.

One criticism of corporotomies is the possible risk for ED. Husmann's report (19) is often cited in that regard. He found

urethral plate transection, single ventral corporotomy with corporal graft, and/or several internal optical urethrotomies for strictures, which can injure the corpora, were associated with ED. He speculated this might result from intracorporal bleeding into a restricted space within the corpora or under the graft (personal communication). In contrast, the 3 corporotomies we perform without corporal grafting likely avoid a compartment syndrome by temporary expansion of the overlying dartos flap placed to contain bleeding (Figure 1).

Ben-Meir et al (20) reported intracorporeal pressures (ICP) during "full" erection with saline injection were significantly less in proximal hypospadias patients who had corporotomies versus others who did not. Of interest, the mean ICP in both groups was less than previously reported in hypospadias patients by Gearhart and Mostwin (21), although within the range measured by Kogan (22) inducing AE with intracorporeal alprostadil. In addition, ICP with "rigid" erections in the Ben-Meir study increased by a similar 3-fold in boys both with and without corporotomies, suggesting corporotomy did not cause venous leak. Therefore, the clinical relevance of their observations is unclear.

In contrast, Badawy and Morsi (23) reported postpubertal

assessment in 16 patients a mean of 10 years after childhood corporotomy with corporal grafting and stated 2 were married with satisfactory sexual activity and 13 others had “rigid erections.” One had decreased erections treated by intraurethral alprostadil.

Our study included older teens and adults who underwent 3 corporotomies. Of the 60 Tanner 4 and 5 patients, only 1 adult reported an adverse change in the quality of his erections: **which he estimated as a “15% decrease” in fullness** and managed with tadalafil. In addition, before 2019 when STAC began, we performed 3 corporotomies in another 19 Tanner 4 and 5 patients. None of them reported erectile difficulties, with 2 having follow up of 23 and 25 years. Of note, **new onset erectile dysfunction** has also been reported in a small minority of adult patients after dorsal plication for congenital penile curvature (24,25). It may be that these anecdotal cases from both corporotomies and dorsal plications really emphasize the need for pediatric urologists to get it right so that these operations can be avoided in adults.

All surgeons managing hypospadias have to use some means for correcting VC to decrease urethroplasty complications and

the future risk for sexual dysfunction related to persistent curvature. The most commonly used include chordee excision and dorsal plication. Chordee excision - removing ventral dartos and the urethral plate - was the mainstay for many years and is still used by some even though intraoperative AE, first described in 1974 (26), proved that even the most complete excision of ventral tissues does not reliably straighten the penis (15). That finding led to the realization that bending is not due to chordee tissues on the surface of the corpora limiting their expansion, but rather to the tunica albuginea of the corpora developing shorter on the ventral side, referred to as "corporal disproportion" (15).

Dorsal plication does not correct this ventral corporal abnormality, but instead seeks to counteract it by shortening the longer dorsal side. Intraoperative AE then typically shows the penis to be straight. However, forces generated during erections that hold the penis firm for penetration can overcome plications done for VC 30° or more, resulting in recurrent curvature (1). Accordingly, while Duckett promoted 1 or multiple plications for nearly all degrees of bending, his successors report limiting it to no more than 15° (16), likely because of

recurrent VC in his patients. Similarly, we previously reported finding that 70% of proximal hypospadias patients with unsuccessful repairs who had dorsal plication for straightening had an average of 40° recurrent curvature, ranging from 30-70° (1). Furthermore, both a scoping review (27) and a meta-analysis (28) comparing dorsal plications to ventral lengthening found corporotomies superior.

The patients in our series undergoing reoperations had less VC than those having primary surgery, a mean of 54° vs 78°. Nearly all of them previously had chordee excision or dorsal plication, and this finding likely indicates only partial correction by those means. In contrast, ventral lengthening directly addresses the short ventral corpora. One option is a single corporotomy with a corporal graft. We found 4 reports of this method in which AE was done at the next stage, totaling 96 patients of which 4 had persistent curvature (29-32). While less than in our series, we continue using 3 corporotomies for several reasons. First, the degree of bending that a single corporotomy can reliably straighten is not known since curvature was not measured in these series. In addition, Gong and Cheng (33) stated a single corporotomy should extend wider than our incisions, reaching

from one neurovascular bundle to the other. Furthermore, there is potential for the corporal graft to contract and cause recurrent VC. Finally, we found persistent or recurrent VC that averaged 54° after single corporotomy with corporal grafting in a third of patients with proximal hypospadias straightened elsewhere using that method (1).

A potential concern regarding 3 corporotomies without corporal grafting is troublesome intraoperative or postoperative bleeding. We found a dartos flap sutured around the perimeter of the incisions and to the isthmuses between them effectively contains bleeding, and presumably allows for expansion by blood without a concomitant rise in intracorporeal pressures during healing. A postoperative elastic bandage also decreases likelihood for bleeding. No patient in this study had intraoperative or postoperative bleeding requiring intervention.

Recently, straightening curvature greater than 30° without corporotomies was reported by Ting et al (34), who excised the urethral plate and then taped the penis on stretch 23 hours daily for at least 6 months. The authors stated their patients had VC a median of 55° (44-74), which decreased to less than 30° in 94%

shown by AE at a second stage procedure. However, later assessment at a median of 19 months found only 76% still had a straight penis and 10% had VC of 30° or more. Whether taping can durably elongate the short ventral corpora is unknown. Furthermore, Ting et al did not report results in boys with more than 75° of bending, which nearly half of our primary patients had.

Regardless how a surgeon chooses to straighten VC, one key message in our study is that repeat AE should be systematically done at second stages to accurately determine results and allow correction of residual curvature. This will also answer those who might question if the risk for recurrent or persistent VC in their patients is similar to what we have documented.

As mentioned above, a possible weakness of our study is the duration of follow-up. However, our average of 17 months after straightening is within the range of other reports concerning VC correction, and our documentation of results using a standardized AE protocol in all patients is a strength found in few other studies. Clearly, the message that follow up AE is needed after prior straightening by whatever means remains important regardless of the length of follow up. While it is possible that

recurrent VC might develop in some of our patients with longer follow up, to date there is little published evidence to suggest that is a high risk.

CONCLUSIONS

Three corporotomies, supplemented with adjuvant dorsal plication in a minority, effectively straightened 99% of VC that averaged 66° and ranged to 135°. This was confirmed by a final AE done an average of 17 months after initial VC correction, and at least 6 months after dorsal plication when that was needed. The finding that VC can persist or recur after any currently used means for correction emphasizes the need for systematic AE during all second stage procedures and reoperations.

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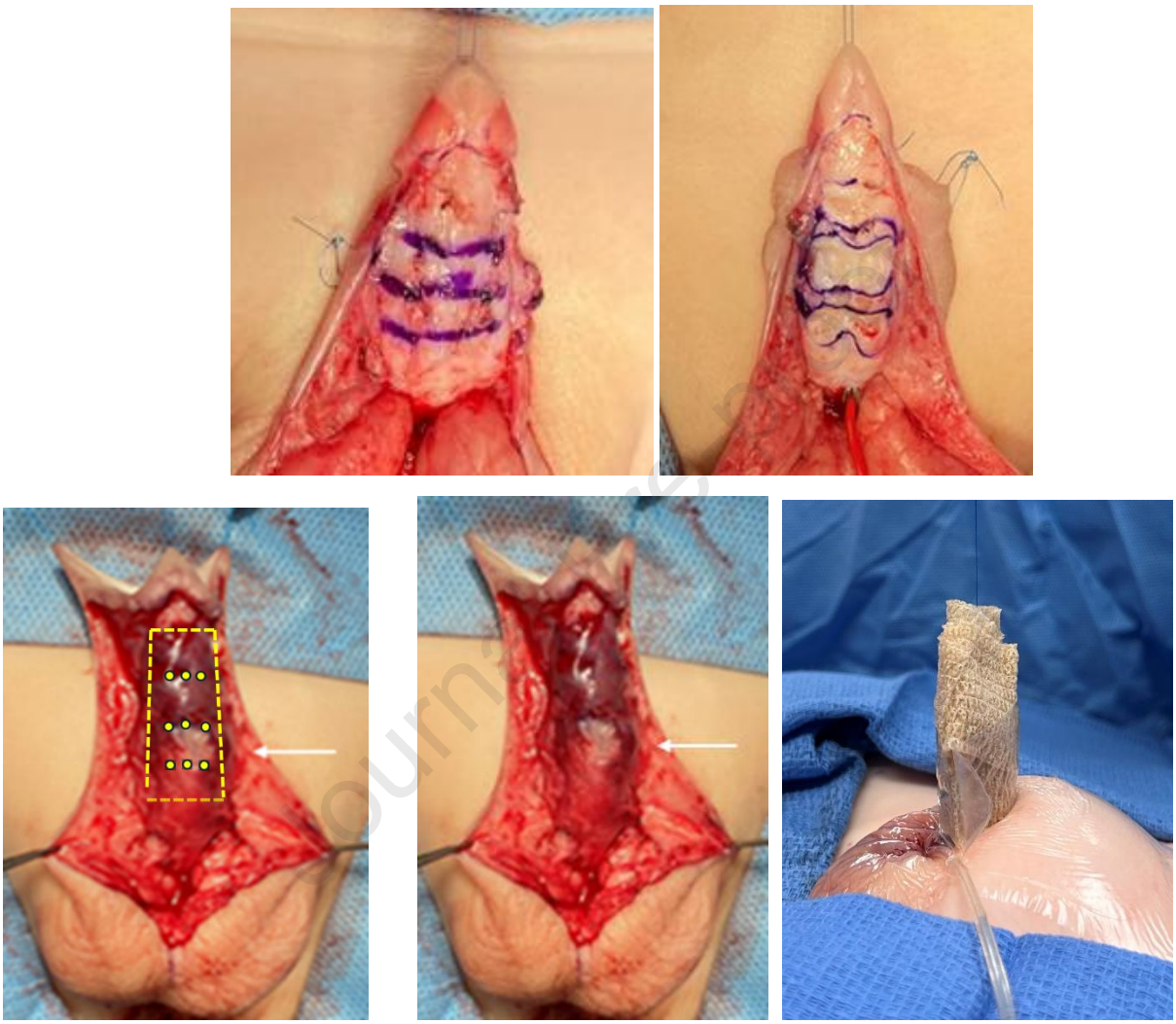
Figure 1

Video and photographs demonstrating the procedure



3 corporotomies

A, lines for the incisions are marked with the middle line across the point of greatest curvature.

B, the 3 incisions have been made from 3 to 9 o'clock extending just through the tunica albuginea

C, approximate location of closely-placed polydiaxanone stitches securing the dartos flap around the incisions (dashed line) and to the isthmuses between them (dots).

D, arrow indicates the urethral plate sutured to the isthmus between the most proximal and middle incisions. The dartos flap distally is sightly distended with blood from the incisions after the tourniquet was released.

E, elastic Coban™ bandage secured with Tegadern™ at the base of the penis to prevent it from lifting off the penis

Patient characteristics	No.	No. undergoing reoperation at time of corporotomies (%)	Initial VC (after degloving) in degrees (SD)	No. patients with any VC at Stage 2 (%)	No. patients with any VC at Stage 3 (%)	No. patients with any VC thereafter (%)	Ave. Time between 1st and Last Artificial Erection (SD)
All	400	163 (40.7%)	66.0° (23.6)	76 (19%)	9 (2.2%)	2 (0.5%)	17.0 (8.5)
Primary	237	0	74.4° (23.7)*	59 (24.9%)	9 (3.8%)	2 (0.8%)	16.7 (8.7)
Redo	163	100%	53.6° (17.1)*	17 (10.4%)	0	0	17.4 (8.1)
Tanner 1	328	96 (27%)	68.7° (24.1)	66 (20.1%)	9 (2.7%)	2 (0.6%)	17.0 (8.6)
Tanner 2-3	12	11 (92%)	55.4° (17.8)	0	0	0	15.0 (6.9)
Tanner 4-5	60	56 (93%)	53.2° (16.0)	10 (16.7%)	0	0	17.3 (8.2)
Initial VC 30-45°	101	69 (68.3%)	38.5° (5.6)	13 (12.9%)^	1 (1.0%)	1 (1.0%)	17.8 (9.2)
Initial VC 46-60°	97	48 (49.5%)	54.9° (4.3)	7 (7.2%)^	0	0	16.1 (5.1)
Initial VC 61-75°	85	32 (37.6%)	69.7° (3.9)	15 (17.6%)^	0	0	16.0 (6.1)
Initial VC 76-90°	54	11 (20.4%)	84.8° (3.9)	14 (25.9%)^	3 (5.6%)	0	18.0 (13.8)
Initial VC 91-135°	63	3 (4.8%)	105.8° (10.1)	27 (42.9%)^	5 (7.9%)	1 (1.6%)	17.3 (8.0)

Table: Patient characteristics by category, including primary versus redo surgery, by Tanner stages, and by initial extent of ventral curvature (VC) after degloving. *p<0.00001 on Mann Whitney U testing. ^p<0.00001 on Chi Square between group analysis.

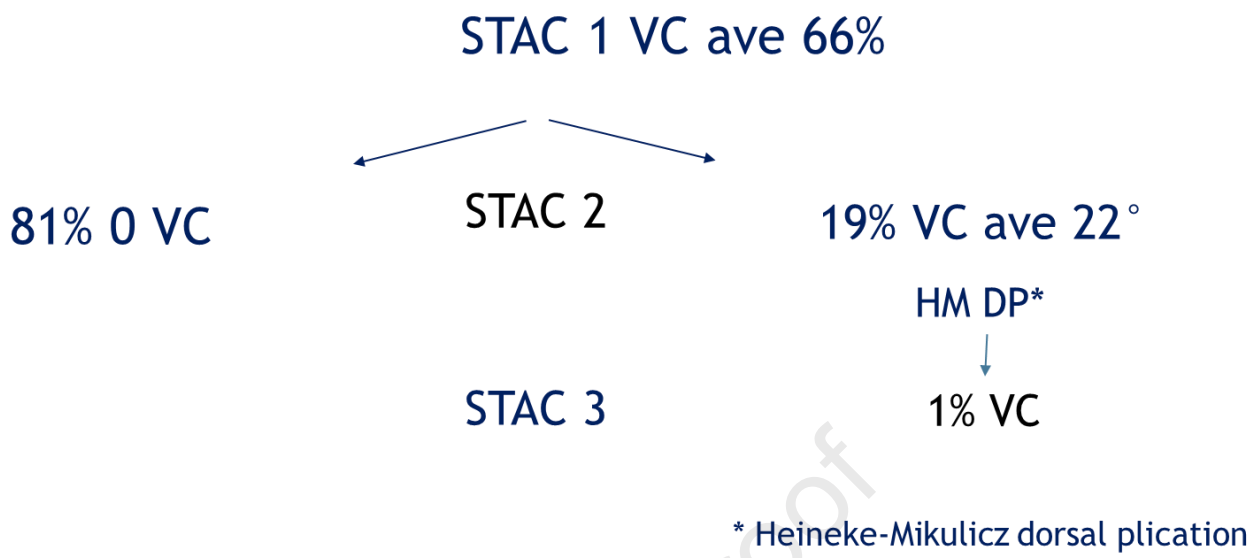


Figure 2. VC after 3 corporotomies during STAC 1

Figure 3. Erections after STAC 3 in boys and men with their original degree of VC