

PEYRONIE'S DISEASE

Practical Computerized Solution for Incision and Grafting in Peyronie's Disease

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ABSTRACT

Introduction: Penile curvature correction with plaque incision and graft (PIG) increases the risk of erectile dysfunction (ED) and is associated with mechanical and geometric abnormalities.

Aims: The aim of this study was to create and validate a new PIG technique using minimum graft area to correct simple or complex penile curvature with or without hourglass deformity, while avoiding mechanical and geometric abnormalities.

Methods: Using our cotton fabric model, we created a mathematic solution for PIG with no residual defects. This was applied in nine men who had sufficient penile rigidity while penetrating their respective partners. They underwent fascia lata patch corporoplasty using the new developed technique (iPad [Apple Corp, Palo Alto, CA, USA] app: iGrafter). Subjects answered the 5-item version of the International Index of Erectile Function (IIEF-5) questionnaire preoperatively and at the end of follow-up.

Main Outcome Measures: The main outcome measures used were patient demographics, erectile function, residual curvature, patient satisfaction, graft area, and complications.

Results: After a mean follow-up of 17.8 months, no significant complication was noted. Complete penile straightening was achieved in all patients. The short side of the penis increased a mean of 3 cm in length, and the mean graft area was 12.4 cm². At the end of the follow-up, three patients developed recurrent deformity. One patient presented severe fibrosis in the corpora cavernosa and severe ED. There was no significant difference between the mean preoperative and postoperative IIEF-5 scores (20.6 vs 19.4, respectively). At the end of follow-up, all patients were able to have sexual intercourse (two with and seven without pharmacological aid). Eight of the nine patients were satisfied with the surgical result.

Conclusion: Penile curvature surgical correction using the iGrafter seems to be an efficient and safe procedure, which uses minimum graft area and preserves erectile function after penile rectification, without resulting in residual deformities. Further research is needed to confirm the efficacy of this procedure.

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Key Words: Peyronie's Disease; Surgery; Graft; Computerized Analysis; Erectile Dysfunction

INTRODUCTION

Surgical correction of Peyronie's disease by plaque incision and graft (PIG) is the best choice of treatment for penile curvature >60°, hourglass defects, and short penis.¹ However, current

techniques (double-Y, H-shape, and their respective variants) may result in geometrical and mechanical abnormalities that may lead to erectile dysfunction (ED), more local fibrosis owing to large graft area, or residual curvature.²

In 2005, Kalsi et al³ reported that graft size was one factor contributing to ED after PIG. In 2011, Flores et al reported some factors such as the use of Egydio's technique⁴ compared with the H-shaped incision and cases with deviation of >60° were associated with worse erectile function (EF) after surgery.⁵ In all situations, a larger graft is needed for defect correction.

In 1991, Gelbard and Hayden⁶ performed PIG instead of excision and grafting that resulted in reduced defect area required to cover the graft and better EF.

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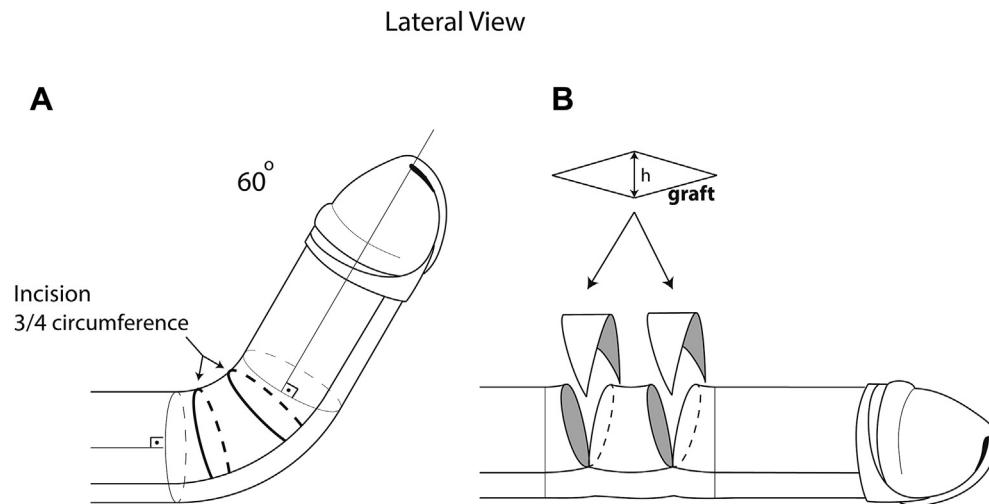


Figure 1. Correction of uniplanar deviation using the iGrafter. (A) Penile curvature of 60° and two transversal lines marking the incisions (three-fourths of the corpora cavernosa circumference each). (B) Penile rectification with two defects to be covered with the lozenge graft. The sum of all graft heights (h) is equal to the difference between the long and short side of the curvature.

AIMS

Our aim was to create and validate a new PIG technique using minimum graft area to correct simple or complex penile curvature with or without hourglass deformity, while avoiding mechanical and geometric abnormalities to achieve better surgical outcomes and minimize complications such as ED.

METHODS

Patients

This study was approved by the Brazilian's Ethics National Committee of Research under the number 0025.0.318.000-11. All patients provided written informed consent for participation in this study.

We included nine men with Peyronie's disease who had been experiencing sufficient penile rigidity while penetrating their respective partners.⁷ Six men had normal EF; one and two men had mild and mild-moderate ED, respectively, (mean age, 48 years; range, 34–68), for which they underwent fascia lata patch corporeoplasty at our hospital between February 2012 and September 2013, which was performed by the same surgeon. The mean follow-up was 17.8 months (range, 6–26 months). The mean penile deviation was 57° (range, 36° – 120°), and the disease had been stable for at least 6 months. Sexual intercourse was dissatisfying in all patients because of the deviation, but they still achieved spontaneous rigid erections that were sufficient to penetrate the partner. The 5-item version of the International Index of Erectile Function (IIEF-5)^{8,9} questionnaire was assessed preoperatively and at the end of the follow-up; patients did not use any medication or device to improve the EF for this assessment.

Technique Research and Development

Using our previously described knitted cotton fabric cylinder model,² we studied different ways to correct penile curvature

without causing mechanical or geometrical distortions and learned the following:

1. To fold a cylinder without causing deformities, at least three-fourths of the cylinder's circumference should be opened.²
2. The easier way to correct a curvature is performing a linear transversal incision and inserting a graft; nevertheless, this reduces the cylinder's diameter on the incision site. However, if we use separate grafts (one graft for each 30° of deviation), the reduction of the diameter is not significant.
3. A lozenge is the simplest geometrical shape (close to an ellipse) to create a graft with the smallest area.

Uniplanar Curvature

The correction was performed using a transversal (linear) incision three-fourths of the corpora cavernosa circumference (one incision for each 30° of deviation) on the shortest side of the curvature. After rectifying the corpora cavernosa, the defect(s) generated on the incision site was closed using a lozenge graft (Figure 1). The sum of the height (h) of all the lozenges should be equal to the difference between the long and short side of the curvature. The grafts should be equally distributed between the beginning and end of the curvature.

For lateral deviations, the same technique was used, but we detached a part of the urethra from the corpora cavernosa on the incision site.

Multiplanar Curvature

Analyzing the four longitudinal cardinal lines present on the corpora cavernosa curvature (dorsal, ventral, right, and left), we selected the two shortest lines. One line was classified as dominant and the other as secondary. The dominant line is the shortest one, and the secondary line is the second shortest line. Figure 2 shows the right side (dominant) and dorsal side

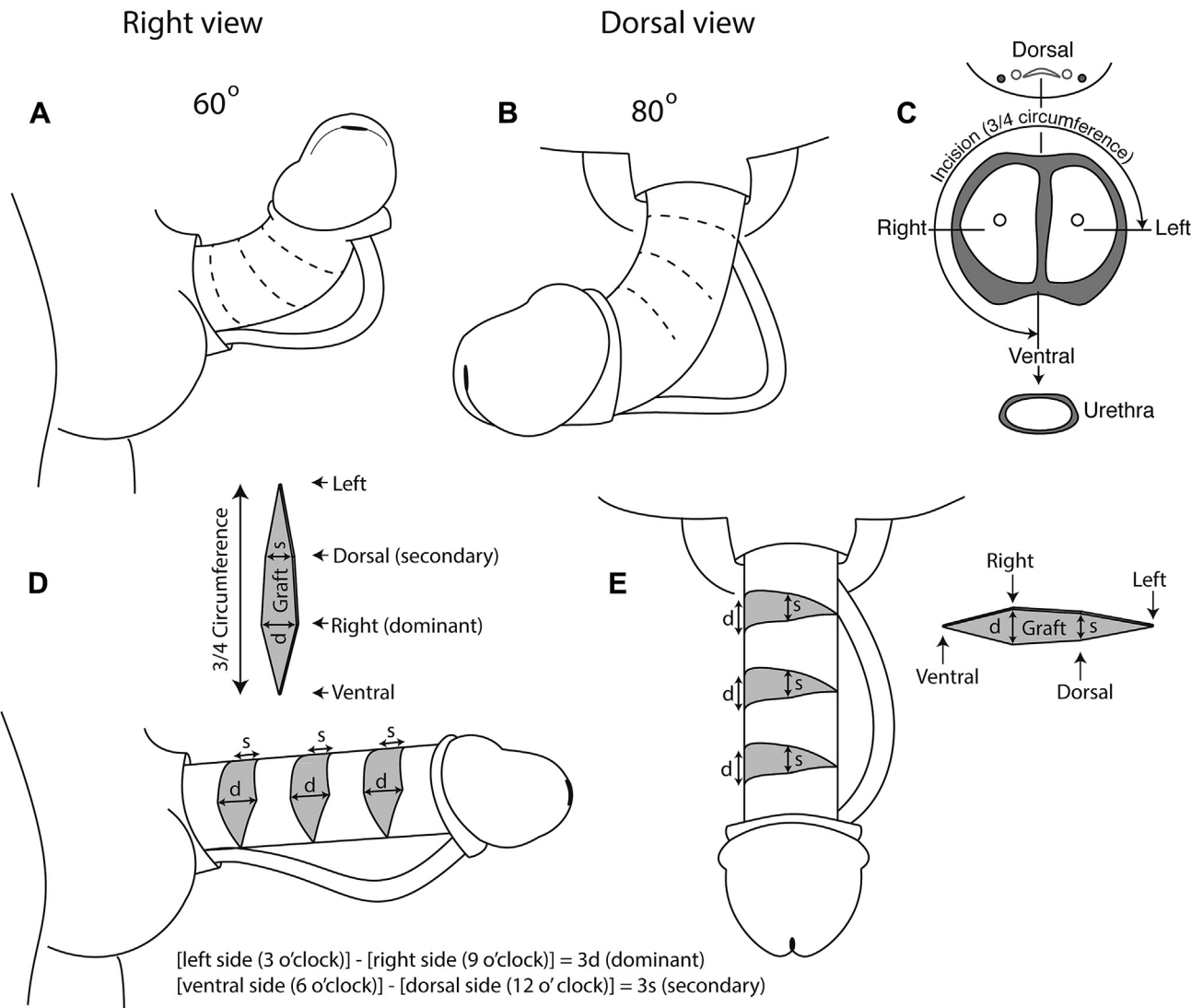


Figure 2. Correction of a multiplanar deviation with 80° right and 60° dorsal deviations using the iGrafter. (A) Right view; (B) dorsal view; and (C) transversal section on the incision site showing the length of the incision (three-fourths of the circumference) and the structures that should be detached from the corpora cavernosa. (D) Right view of the rectified penis with grafts closing the defects. The sum of all dominant graft heights (d) is equal to the difference between the left and right cardinal lines and the sum of all secondary heights (s) is equal to the difference between the ventral and dorsal cardinal lines on the curvature. (E) Dorsal view of the rectified penis with the grafts closing the defects.

(secondary). To perform the transversal incision needed to rectify the corpora cavernosa, we started detaching the urethra from the corpora cavernosa just on the incision(s) site(s). Then, we made a transversal incision connecting two cardinal points (dorsal-right, dorsal-left, ventral-right, and ventral-left) of the dominant and secondary lines (one-fourth of the circumference). The second step is extending that incision to the next cardinal point to each side (one-fourth of the circumference to each side) (Figure 2A–C). The total length of the incision will be three-fourths of the corpora cavernosa circumference. The transversal incisions should be equally distributed on the corpora cavernosa curvature (Figure 2A–B).

The deviation was classified as primary and secondary. The primary angle shows the largest deviation, and the secondary angle shows the second biggest deviation. To calculate the number of grafts needed, we used the dominant angle (one graft

for each 30° of deviation). In Figure 2D–E, three grafts were required ($80^\circ/30^\circ = 2.67$, rounded to 3).

The multiplanar graft has two heights: one should be inserted on the dominant line, called dominant height (d), and the other should be inserted on the secondary line, called secondary height (s) (Figure 2D–E). The sum of all dominant heights (d) should be equal to the difference between the dominant line and the contralateral line (Figure 2). Using the same principle, the sum or all secondary heights (s) should be equal to the difference between the secondary line and contralateral line.

Hourglass Deformity

We measured the corpora cavernosa normal circumference (C1) and the point of the maximum narrowing (C2) (Figure 3).

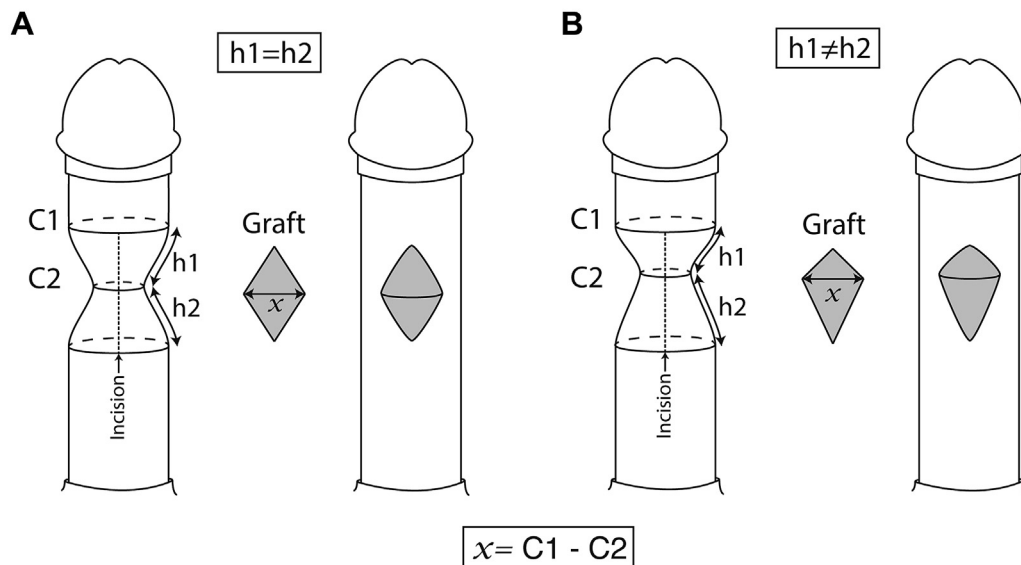


Figure 3. Correction of hourglass defects using the iGrafter. (A) Symmetrical defect with equal distance from the narrowest central part to the distal ($h1$) and proximal ($h2$) normal circumference. The defect is closed with a symmetrical graft and its transversal width (x) is equal the difference between the normal ($C1$) and narrowest ($C2$) circumferences. (B) The asymmetrical defect ($h1 \neq h2$) is closed with an asymmetrical graft with its transversal width (x) equal to the difference between the normal ($C1$) and narrowest ($C2$) circumferences.

The hourglass defect can be symmetrical on a longitudinal axis presenting an equal distance from the narrowest central part to the distal ($h1$) and proximal ($h2$) normal circumference ($h1 = h2$) (Figure 3A), or it can be asymmetrical with different distance from the narrowest central part to the distal ($h1$) and proximal ($h2$) normal circumference ($h1 \neq h2$) (Figure 3B). The graft can be symmetrical or asymmetrical depending on the defect shape. The graft's transversal width (x) is equal to the difference between $C1$ and $C2$, and the height should be equal to the longitudinal linear incision made from the beginning to the end of the hourglass deformity.

Curvature with Hourglass Deformity

These complex deformities can be corrected using a combination of the hourglass solution with uniplanar or multiplanar solutions (Figure 4). We calculated the hourglass graft size followed by that of the planar graft (multi or uniplanar depending on the case), as previously described. The second step is to split the hourglass graft into two triangles. The base of the triangles (x) should be equal to the difference between the normal ($C1$) and the narrowest ($C2$) circumference of the corpora cavernosa (Figure 4C). The final graft merges with the planar graft with the triangle resulting from the hourglass graft division (Figure 4C). The longitudinal incision to correct the hourglass deformity should be placed on the corpora cavernosa side with more pre-eminent depression caused by the hourglass (Figure 4A–B), because the tunica albuginea is attached to erectile tissue with limited accommodative capacity to distribute the additional tissue.

Computerized Solution: iGrafter

To facilitate the application of the previously described principles, avoid complex calculations, save time, and guarantee

surgical technique precision, we developed a free web app based on JavaScript (Oracle Corp, Santa Clara, CA, USA) to iPad (Apple Corp, Palo Alto, CA, USA), named iGrafter. It is freely available at <http://www.igrafter.net>. In the surgical field, the iPad should be inserted inside a transparent and sterile plastic bag.

The values corresponding to the corpora cavernosa longitudinal size on each cardinal point (dorsal, ventral, right, and left), between the beginning and end of the curvature, as well as the penile circumference should be inserted into the app (Figure 5A). If hourglass deformity is present, click on the “hourglass” button and another screen will appear with new fields to be filled with the values of normal circumference ($C1$), narrowest circumference ($C2$), and longitudinal distance from the narrowest central part of the defect to distal ($h1$) and proximal ($h2$) normal circumference (Figure 3). In hourglass defect cases, one of the following buttons in the iGrafter should be chosen: $h1 = h2$ or $h1 \neq h2$. After data analysis, the iGrafter will recognize the case as uniplanar or multiplanar and calculate the deviation angle(s), incision length, graft size and shape, graft area (cm^2), and the site(s) where the incision(s) should be done for graft insertion. The results appear in graphic form on the iPad screen (Figure 6A).

The two rules on the top of the screen mark the transversal plane where the incision should be performed. The short ruler should be placed on the shortest size and the long rule on the long size of the corpora cavernosa curvature (Figures 5D and 6G). Connecting the corresponding mark on each ruler, a plane can be traced to perform the incision (Figures 5E–F and 6G). In multiplanar deviation cases, the rulers should be placed on the dominant cardinal line and contralateral line.

The iPad screen shows the graft in real size (scale 1:1) and the number of grafts that should be used (n) (Figure 6A). The

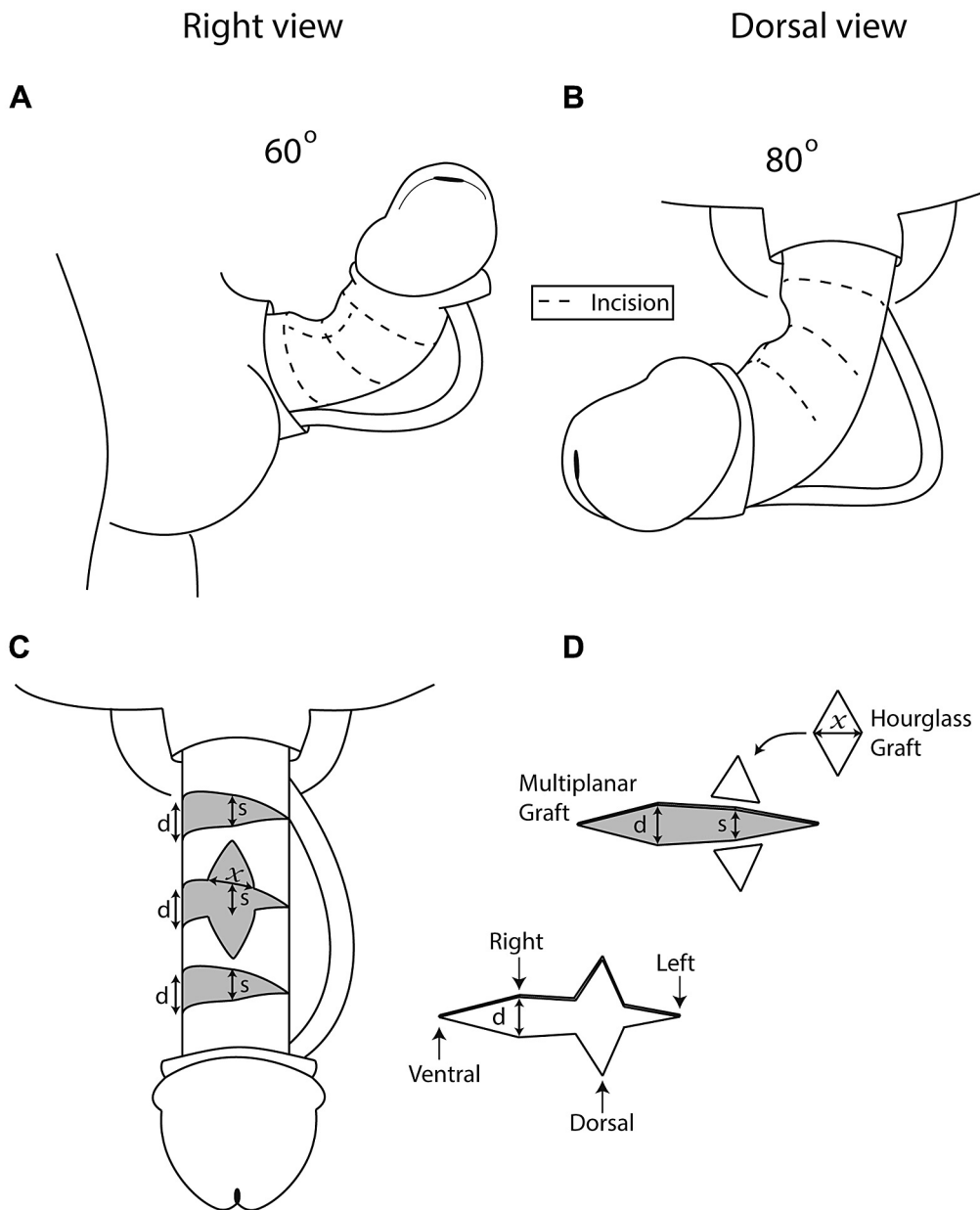


Figure 4. Correction of a complex case with multiplanar and hourglass defect using the iGraft. (A) Right view showing a 60° dorsal deviation with an hourglass defect, and dash lines represent incisions (B) Dorsal view showing a 80° right deviation and an hourglass defect, and dash lines represent incisions. (C) Dorsal view showing the graft closing the defects after penile rectification and caliber restoration. (D) Creation of the composed graft merging the planar graft with the hourglass graft, which should be split in two triangles with a base width (x) equal to the difference between the normal and narrowest circumferences.

surgeon can use a plastic sheet over the iPad's screen to copy the shape that appear, using transillumination to create a plastic mold. This mold is used to create a graft (with the material of his/her choice) with the same shape and size as that shown on the screen (Figure 5B). We used methylene blue around the plastic mold to copy this shape on graft material (Figures 5C and 6D–E).

At the bottom of the iPad screen, a third ruler appears with the width of the incision (three-fourths of the circumference) (Figure 6A). In uniplanar cases, the middle point will have a mark that should be placed on the shortest cardinal line in the

curvature to mark the incision. In multiplanar cases, the ruler is divided into three segments of one-fourth of the circumference. On the lateral side of the screen, a transversal section of the penis shows where the ruler should be positioned to mark the incision.

Analysis of the Curvature

Under artificial erection, during the surgery, we analyzed the degree of penile deviation using Kelami's classification.¹⁰ At the end of the follow-up, we measured it again after inducing an erection with intracavernous injection (ICI) of alprostadil 10 µg.

Table 1. Characteristics and comparison of surgical outcomes of patients undergoing PIG using the iGrafter technique

Patient	Age (year)	Deviation (degrees)	Hourglass	IIEF-5 pre-op	IIEF-5 post-op	Graft area (cm ²)	Graft number	Ossification side	Length gain—shortest side (cm)	Follow up (months)	Surgical outcome	Treatment
1	63	60-L	x	23	25	8	2	x	2	26	Straight	
2	62	50-D 33-L	x	19	21	11.7	2		3	26	Straight	
3	47	45-D		22	23	7.5	2		2	26	After 4 mo bend 46°	New graft surgery
4	49	63-D		12	10	16.6	2	x	4	26	Straight	PDE5i
5	54	120-D	x	24	19	23	4		6	22	After 12 mo bend 38°	L
6	37	38-R		23	21	7.5	2		2	22	Straight	
7	55	50-L	x	22	22	13.8	2		3	13	Straight	
8	50	36-D	x	16	10	13.3	2		2	11	Corpora cavernosa severe fibrosis + ED	ICI of alprostadil 10 µg
9	31	51-D	x	24	24	10	2		3	6	After 3 mo hourglass	
Mean	48	57		20.6	19.4	12.4	2.2		3	17.8		

D = dorsal; L = left; R = right; ICI = intracavernous injection; PDE5i = phosphodiesterase 5 inhibitor; mo = month; IIEF = International Index of Erectile Function; PIG = plaque incision and graft.

Operative Technique

Artificial erection was induced with 0.9% of NaCl solution injected into the corpora cavernosa puncture with a 21-G butterfly needle. Austoni's technique was used to deglove the penis and isolate the neurovascular bundle.¹¹ We used the iGraft app as previously described to correct the penile curvature using PIG. The graft material was autologous fascia lata. A longitudinal incision was performed on the lower and lateral part of the non-dominant leg to obtain access to the fascia lata (Figure 6C). Methylene blue was used to mark the fascia lata around the plastic mold (Figure 5C). The marked fascia lata was removed using a scalpel (#11 blade) (Figure 6D–E). The defect created was closed primarily (Figure 6F). In three cases, the harvest area was too large; therefore, we used a surgical mesh to close it. If ossification occurred, it was excised to correct the penile curvature, sparing the tunica albuginea.¹²

The graft(s) generated by iGrafter was used to cover the corpora cavernosa defect(s) created and was fixed with 5-0 polydioxanone running sutures (Figures 5G and 6H). Buck's fascia was closed with separate sutures using the same material after inserting a 14F Jackson-Pratt drain into the scrotum. The bladder was drained with a Foley catheter, and a contensive bandage was placed around the penis.

The catheter and bandage were removed after 4 days to achieve inosculation of the fascia lata graft. We recommended restarting sexual activity in approximately 6 weeks.

Statistical Analyses

Descriptive data on the demographic and penile deviation-specific information is presented in Table 1. Preoperative and postoperative IIEF-5 scores were compared, and their differences were analyzed using a paired Student's *t*-test. A *P* value of $\leq .05$ was considered statistically significant.

MAIN OUTCOME MEASURES

The main outcome measures used were patient demographics, EF, residual curvature, patient satisfaction, graft area, and complications.

RESULTS

No significant complication was noted, except in one patient who presented a mild glans hypoesthesia, which reversed after 2 months.

Six weeks after surgery, complete penile straightening was achieved in all patients; the mean increase in length on the short side of the penis was 3 cm (range, 2.0–6.0), and the mean graft area was 12.4 cm² (range, 7.5–23.0) (Table 1). All patients achieved satisfactory sexual intercourse without any medication such as phosphodiesterase type 5 inhibitors or ICI. At the end of the follow-up, the deformity recurred in three patients. One

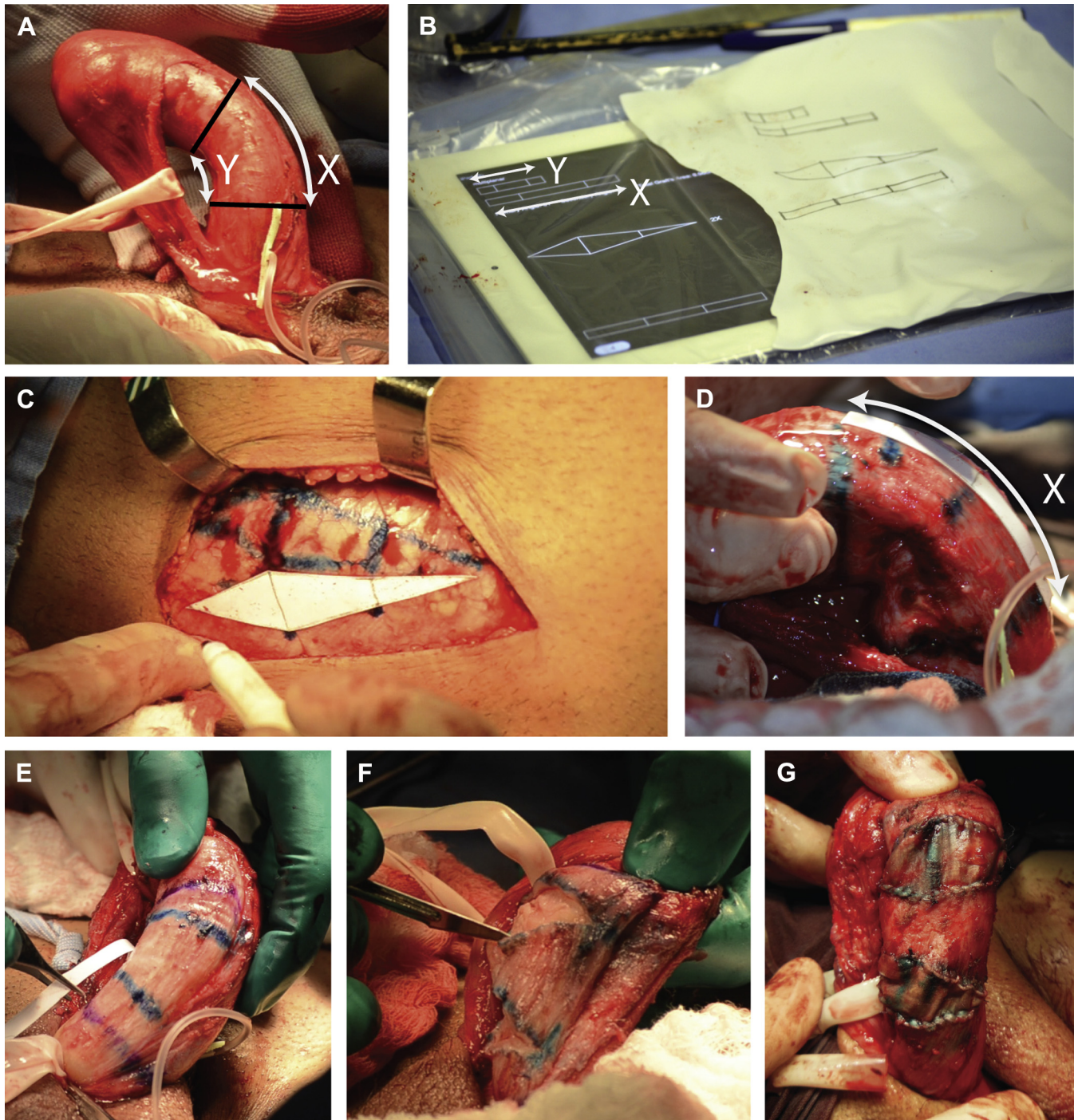


Figure 5. Surgical steps. (A) Right view showing penile curvature after Austoni's penile deglove and neurovascular bundle isolation, under artificial erection. X—long size of penile curvature. Y—short size of penile curvature. (B) After calculation, the iGrafter's results appeared on iPad screen and were copied on a semi-transparent plastic sheet by transillumination, using a sterile pencil. X—long rule with size equal to the long size of penile curvature. Y—short rule with size equal to the short size of penile curvature. (C) Two grafts were marked with methylene blue on fascia lata, using the graft mold. (D) The long rule was placed on the long size of the penile curvature to mark the points of the incision plane. (E) Incisions marked on penile curvature, created after connecting the dots marked on each side of penile curvature, indicated by the rules. (F) Corpora cavernosa linear incision on a previous marked sites. (G) Final appearance after the corpora cavernosa defects was covered by grafts.

patient presented severe fibrosis in the corpora cavernosa as well as severe ED.

There were no significant differences between the mean preoperative and postoperative IIEF-5 scores (20.6 [range, 12–24]

vs 19.4 [range, 10–24], respectively; $P = .28$). Four patients had worse postoperative IIEF-5 scores, with a mean reduction of 3.8 (range, 2–6). At the end of the follow-up period, all nine patients were able to have sexual intercourse: seven without any

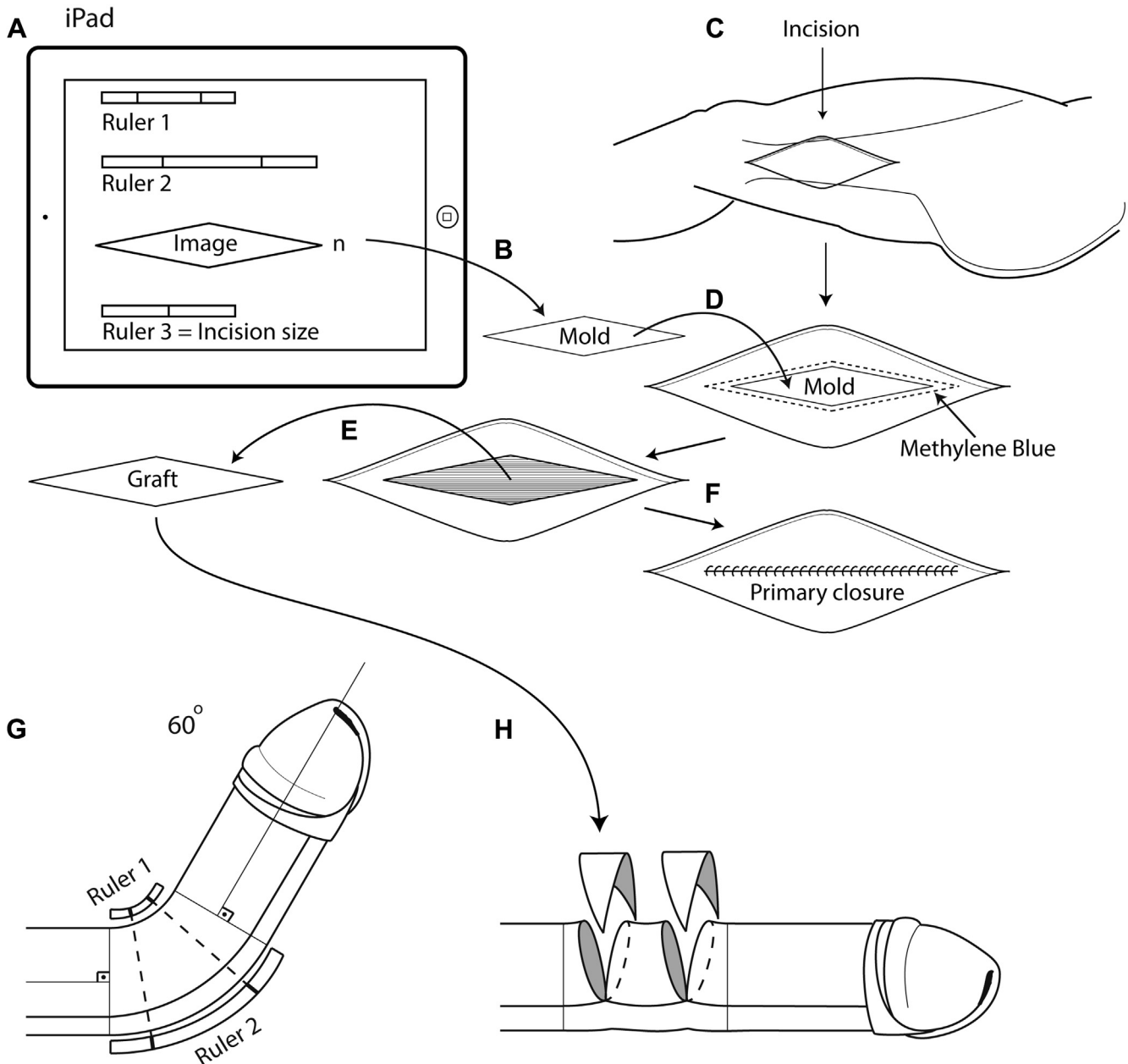


Figure 6. iGrafter workflow. (A) Results for a uniplanar curvature. The rulers needed to mark the incision plane appear on the top of the screen; the second ruler shows the graft in real size (1:1 scale) and the required number (n) of grafts; and the third ruler shows the incision size, marked on the middle. (B) Graft mold created by copying the iPad screen, using transillumination. (C) Longitudinal incision on the lateral part of the leg to access the fascia lata. (D) Methylene blue was used to mark the fascia lata around the plastic mold. (E) The marked fascia lata was removed using a scalpel (#11 blade). (F) The defect created was closed primarily. (G) Connecting the corresponding mark on each ruler, we can trace a plane to perform the incision. (H) Graft being placed in position to cover the corpora cavernosa defects.

erectogenic drug and one using sildenafil 50 mg orally and the other, ICI of alprostadil 10 μ g (Table 1).

All patients, except one, were satisfied with the surgical result. The unsatisfied patient was the one who needed an ICI to have sexual intercourse.

DISCUSSION

The use of grafts for correcting Peyronie's disease was first described in 1950,¹³ and since then, many materials and

different techniques have been proposed with variable results.^{3,14–17} Our present work is not about the material for grafting, but it focused on the technique of opening the corpora cavernosa, which enabled graft area reduction and avoided geometric and mechanical abnormalities. The reduction of the defect area on the corpora cavernosa was first considered when urologists changed from an excisional to incisional approach for correcting the curvature in Peyronie's disease, reducing the graft area, with better outcomes.^{6,18,19}

Although several authors describe postoperative ED to vary from 21% to 100%,^{3,7,20–23} few have used validated tools to assess ED. Flores et al,²² using the IIEF, reported that 46% of men experienced a >6-point decrease in the IIEF-EF domain (IIEF-EF) score after PIG. The baseline and postoperative EF domain scores were 23 ± 4 and 17 ± 9 , respectively. Chung et al,²⁰ using the IIEF-5, reported that the average preoperative and postoperative scores were 15.1 (6–20) and 10.8 (2–15). After 5 years, all patients who received PIG had a worse IIEF-5 scores, and 67% utilized phosphodiesterase type 5 inhibitors or intracavernous agents. Our results show a better EF, with seven of nine patients achieving sufficient erection to have sexual intercourse without pharmacological aid. The four patients with worse postoperative IIEF-5 score presented less preeminent reduction of the IIEF-5 score (mean, 3.8), and only two patients needed pharmacological aid. Among the patients with worse postoperative EF, two had mild-moderate ED preoperatively (IIEF-5 12–16), and one had 120° of curvature; these factors represent a high risk of postoperative ED.^{7,22} At the end of the study, all nine patients with or without erectogenic drugs, were able to have sexual intercourse.

The iGrafter proved to be a precise tool for intraoperative calculations in PIG and presented some advantage to correct the penile curvature. The iGrafter app performs complex calculations and aids better distribution of the incisions along the penis with incisions and graft insertions each at 30° and not in a single region. This technique is especially important in large deviations to avoid large defects and trauma to the tunica albuginea and the subjacent erectile tissue. The method is also flexible, which enables its use in any type of penile curvature such as Peyronie's disease with or without a prosthesis insertion, congenital penile curvature, and any other penile tortuosity. The iGrafter also enables the use of any type of graft material, allowing the surgeon to choose the graft material.

While urologists have been concerned about the ideal material for grafting, little attention has been paid to the graft area and the geometrical and mechanical abnormalities. Our new approach addressed these problems and seems to present excellent curvature correction and EF preservation, when applied to well-selected patients (good preoperative EF). The present work is an original contribution for a minimalist solution to PIG with promising results. The study limitations include the small patient number used for analysis, the lack of a control group, the short follow-up period (less than 5 years), and not well-selected patients (all with good EF).

CONCLUSION

The use of the iGrafter seems to be a promising, efficient, and safe solution for the surgical correction of penile curvature, and the graft area can be reduced significantly without residual deformities, while preserving sexual function. More well-designed studies are needed to confirm our findings.

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