Hum. Reprod. Advance Access published January 16, 2015
Human Reproduction, Vol.0, No.0 pp. 1–9, 2015
doi:10.1093/humrep/deu341

human reproduction
ORIGINAL ARTICLE *Gynaecology*

Sexual and functional outcomes of vaginoplasty using acellular porcine small intestinal submucosa graft or laparoscopic peritoneal vaginoplasty: a comparative study

Jing-Xin Ding[1,2,†], Li-mei Chen[1,2,†], Xu-yin Zhang[1,2], Ying Zhang[1,2], and Ke-Qin Hua[1,2,*]

[1]Department of Gynecology, Obstetrics and Gynecology Hospital of Fudan University, Shanghai 200011, China [2]Shanghai Key Laboratory of Female Reproductive Endocrine Related Diseases, Shanghai 200011, China

*Correspondence address. Department of Gynecology, The Obstetrics and Gynecology Hospital of Fudan University, 419 Fang-Xie Road, Shanghai 200011, China; Shanghai Key Laboratory of Female Reproductive Endocrine Related Diseases, Shanghai, 200011 China. Tel: +86-15921515900; Fax: +86-21-63455090; E-mail: huakeqin@126.com

Submitted on June 2, 2014; resubmitted on November 1, 2014; accepted on December 1, 2014

STUDY QUESTION: Can vaginoplasty in patients with Mayer–Rokitansky–Küster–Hauser syndrome (MRKHS) be achieved using an acellular porcine small intestinal submucosa (SIS) graft?

SUMMARY ANSWER: Vaginoplasty using SIS graft was successfully achieved in women with MRKHS, and the anatomical and functional outcomes of this procedure were comparable to those of laparoscopic peritoneal vaginoplasty.

WHAT IS KNOWN ALREADY: There is a great variety of vaginal reconstruction techniques, which suggests there is no single superior surgical technique.

STUDY DESIGN, SIZE, DURATION: This prospective observational study included 34 patients with congenital vaginal agenesis who underwent vaginoplasty using SIS graft (the SIS group) between December 2011 and July 2013, and 41 patients with the same disease who underwent laparoscopic peritoneal vaginoplasty (the Davydov group) between January 2008 and July 2013.

PARTICIPANTS/MATERIALS, SETTING, METHODS: Patient and surgical data, follow-up information, and the female sexual function index (FSFI) scores in the two groups were analysed and compared.

MAIN RESULTS AND THE ROLE OF CHANCE: Compared with the laparoscopic Davydov procedure, the operating time of vaginoplasty using SIS graft was significantly shorter, and the estimated blood loss was significantly less. Patients in the SIS group had an earlier return of bowel activity, and an earlier return to work. However, the total cost in the SIS group was significantly higher than that in the Davydov group due to the cost of the SIS graft ($3525 per graft). Most patients (28/34 in the SIS group and 37/41 in the laparoscopic Davydov group) returned for their follow-up 9 months post-surgery. The mean length of the neovagina in the SIS group seemed slightly shorter than that in the Davydov group (6.8 ± 0.9 cm versus 7.3 ± 1.3 cm, $P = 0.081$). Thirteen patients (46%) in the SIS group and 11 (29%) in the Davydov group had a neovagina <7 cm long ($P = 0.453$), whereas 4 patients (14%) in the SIS group and 3 patients (8%) in the Davydov group had a neovagina <6 cm long ($P = 0.201$). Sixteen patients in the SIS group and 25 in the Davydov group subsequently had a sexual partner and became sexually active. Four patients in the SIS group and six in the Davydov group reported low total FSFI scores (≤ 23). There was no statistically significant difference in the total FSFI scores and the scores of all six domains of the FSFI between the two groups. The average time of continuous mould wearing in the SIS group was statistically significantly longer than that in the Davydov group (7.8 ± 3.3 months versus 4.8 ± 1.6 months, $P = 0.001$). In the patients with a neovaginal length of ≥ 6 cm, the FSFI score of the women (26.6 ± 2.3 versus 21.5 ± 1.5, $P < 0.001$) and the satisfactory score of their partner (8.6 ± 1.2 versus 6.6 ± 1.2, $P < 0.001$) were both statistically significantly higher than patients with a neovaginal length of <6 cm.

[†] The authors consider that the first two authors should be regarded as joint First Authors.

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LIMITATIONS, REASONS FOR CAUTION: The main limitation of this study is that it is non-randomized. Further randomized studies are warranted to compare the effects of these two procedures.

WIDER IMPLICATIONS OF THE FINDINGS: Despite the need to wear a mould for longer, vaginoplasty using SIS graft provides an attractive, alternative treatment for women with MRKHS.

STUDY FUNDING/COMPETING INTEREST(S): This study was supported by the Chinese National Nature Sciences Foundation (grant number 81471416) and the National Key Clinical Faculty Construction Program of China. No competing interests are declared.

TRIAL REGISTRATION NUMBER: N/A.

Key words: vaginoplasty / Mayer–Rokitansky–Küster–Hauser syndrome / acellular porcine small intestinal submucosa graft / laparoscopic peritoneal vaginoplasty / the Davydov procedure

Introduction

Mayer–Rokitansky–Küster–Hauser syndrome (MRKHS) is characterized by vaginal agenesis, with variable Müllerian duct abnormalities and normal secondary sexual characteristics. The incidence is estimated to be 1 in 4000–10000 live born girls (Rock and Azziz, 1987).

When sexual activity is desired, treatment for vaginal agenesis in MRKHS patients involves the creation of a vagina. Several therapeutic modalities are available, ranging from the non-surgical use of serial vaginal dilators to various reconstructive techniques. The Abbè–McIndoe–Reed vaginoplasty consists of creating a vaginal canal by dissecting the potential neovaginal space, which is subsequently covered by a skin graft. The main disadvantages associated with this procedure are the surgical complexity and the remnant scar on the donor site. Several modifications of this technique, especially regarding the material adopted for the canal lining, have been proposed. These include the use of the peritoneum (Rothman, 1972; Davydov and Zhvitiashvili, 1974), the amnion (Dhall, 1984; Templeman and Hertweck, 2000), allogenic epidermal sheets (Carranza-Lira *et al.*, 1999), Interceed® (Jackson and Rosenblatt, 1994; Inagaki *et al.*, 2009), autologous buccal mucosa (Lin *et al.*, 2003), bowel (Urbanowicz *et al.*, 2004; Wedler *et al.*, 2004) and autologous *in vitro* cultured vaginal tissue (Panici *et al.*, 2007).

There is a great variety of vaginal reconstruction techniques, which suggests there is no single superior surgical technique. Currently laparoscopic peritoneal vaginoplasty (the Davydov technique), laparoscopic sigmoid vaginoplasty and a modified laparoscopic Vecchietti technique compete for popularity (Giannesi *et al.*, 2005).

The acellular porcine small intestinal submucosa (SIS) is one kind of extracellular matrix(ECM)-based collagen material, which is harvested from the submucosal layer of porcine small intestines. The graft is acellular and composed of noncross-linked collagen (types I, III and V), glycosaminoglycans, proteoglycans, glycoproteins and multiple growth factors (Soiderer *et al.*, 2004). Studies have demonstrated tissue incorporation and neovascularisation of SIS in both animal herniae and subcutaneous models (Soiderer *et al.*, 2004; Ayubi *et al.*, 2008).

In this prospective follow-up study, we present our successful experiences of vaginoplasty using SIS graft in 34 patients with MRKHS, and compare the effectiveness and long-term anatomical and functional results of this procedure with laparoscopic peritoneal vaginoplasty.

Materials and Methods

Patients

Between December 2011 and July 2013, a total of 34 patients with a diagnosis of MRKHS, who were admitted to the Obstetrics and Gynecology Hospital of Fudan University, underwent vaginoplasty as a primary procedure with the use of SIS graft (the SIS group). The diagnosis was made using comprehensive laboratory procedures that involved sex steroid hormone levels, chromosomal analysis, ultrasonography, intravenous pyelography and magnetic resonance imaging. No chromosomal abnormality was noted in all the subjects. After appropriate counselling regarding the methods, as well as possible complications, vaginoplasty using SIS graft was decided upon following the patients' own choice. All patients gave their informed consent before the surgical intervention. Patients and surgical data, follow-up information, and the female sexual function index (FSFI) scores were recorded, analysed and compared with those of 41 patients with the same disease who chose to undergo laparoscopic peritoneal vaginoplasty (the Davydov group) between January 2008 and July 2013. This study was approved by the Institutional Review Board of Obstetrics and Gynaecology Hospital of Fudan University.

Surgical procedures

Vaginoplasty using SIS graft

Preoperatively, the patients were given antibiotic prophylaxis and a bowel enema. In the operating theatre, the patient was placed in the lithotomy position. Three hundred millilitres of normal saline containing 2.0 mg of phenylephrine and methylthioninium chloride (blue dye) was injected along the anatomical vaginal route between the bladder/the urethra and the rectum. During the injection, one figure of the operator was inserted in the anus, to ensure that there was no injury to the rectum. And at the same time, a metal urinary drainage tube was inserted into the urethra and bladder to check for any outflow of the blue dye through the tube, to ensure that there was no injury of the urethra or bladder. Then a midline incision at the vaginal introitus was made, and an 8.5 cm long canal was created using blunt dissection along the anatomical vaginal route. Care was taken to achieve hemostasis. A 20 × 7 cm SIS graft (Surgisis®, Cook Medical, Bloomington, IN, USA) was trimmed and sutured with 2/0 PDS II delayed absorbable material (Ethicon, Somerville, NJ, USA), to wrap around a vaginal mould of 2.5 cm in diameter and 8.5 cm in length. The mould covered by the SIS graft was placed in the neovagina, and the SIS graft was sutured to the vestibular mucosa. The mould was fixed to the perineum with stitches bilaterally. At the end of the procedure, a Foley catheter was inserted, and the mould was kept in place for 7 days post-operatively, after which vaginal douching was performed and the mould was changed every 3 days. Patients were instructed to wear the vaginal mould continuously over the following 6 months, then for 1 h daily, until they had sexual activity at least twice a week. If the woman was sexually inactive her vagina was dilated for 1 h twice per week.

Laparoscopic peritoneal vaginoplasty

The surgical procedure used was the peritoneal vaginoplasty procedure described by Liu *et al.* (2009).

Daily vaginal douching was performed. The patients were instructed to wear the vaginal mould continuously over the following 3 months, then for 1 h daily, until she had sexual activity at least twice a week.

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Follow-up

The patients were followed up monthly in the first 3 months after surgery, then every 3 months in the first year and thereafter biannually. The cosmetic outcome was assessed, and neovaginal diameters and lengths were measured. Anatomical success was defined as a neovagina into which two fingers could be inserted easily and with a length >6 cm (Fedele *et al.*, 2000, 2010; Cao *et al.*, 2013). The quality and structure of the neovaginal epithelium were evaluated by visual inspection, without biopsy, during gynaecological examinations. Post-operative outcome and sexual function were assessed using the FSFI (Rosen *et al.*, 2000), a self-reported questionnaire commonly used to evaluate the sexual life of female patients. And the sexual satisfaction score of the male partner of the patients was assessed using the visual analogue scale (VAS).

All data were entered into a Microsoft Excel database, and their quality and integrity were rigorously checked.

Statistical analysis

Statistical analyses were performed using SPSS 16.0 software (SPSS, Inc., Chicago, IL, USA). Data are expressed as the mean ± standard deviation (SD). Student's *t*-test was used to compare quantitative variables; Fisher's exact test and the chi-square test were used to compare categorical variable. Differences were considered to be statistically significant at $P < 0.05$.

Results

Perioperative data

Thirty-four patients who underwent vaginoplasty using SIS graft (the SIS group) were compared with 41 patients who underwent laparoscopic Davydov procedure (the Davydov group). The mean preoperative vaginal length was 0.21 ± 0.59 (0–3) cm in the SIS group, and 0.67 ± 1.0 (0–3) cm in the Davydov group. The clinical characteristics of the two groups are shown in Table I. One patient had a pelvic kidney, and one had a unilateral kidney in the SIS group, whilst two patients in the Davydov group had a unilateral kidney. In addition, one patient in the Davydov group had a previous appendectomy. All patients had normal secondary sexual characteristics. Two patients in the SIS group, and two in the Davydov group, had a concomitant urinary anomaly. Two patients in the Davydov group, and none in the SIS group, had functional endometrium.

Previously, the laparoscopic Davydov procedure was the standard procedure at our institution. With the introduction of the SIS graft, vaginoplasty with this material was gradually becoming more popular. The perioperative data of the two groups are summarized in Table II. Surgical vaginoplasty was successfully completed in all patients with no complications or transfusion requirements. Compared with the laparoscopic Davydov procedure, the operating time of vaginoplasty using SIS graft was significantly shorter (30.2 ± 5.2 min versus 118.5 ± 43.3 min, $P < 0.001$). We also evaluated the learning curve for vaginoplasty using a SIS graft and found the lowest number of repeat procedures required to learn the technique was 3, with no significant difference between the early learning curves of the two surgeons (Surgeon 1, K.H.; Surgeon 2, J.D.) (Fig. 1). Fast learning was possible due to the familiarity and experience (at least 30 previous cases) with the Davydov procedure of both surgeons, prior to starting the vaginoplasty procedure.

Two patients in the Davydov group who had a rudimentary horn with a functional endometrium (ESHRE/ESGE Class U5a/C4/V4) underwent excision of the horn at the same time (Grimbizis *et al.*, 2013), and one

Table I **Clinical characteristics of the two groups.**

Parameter	Vaginoplasty using SIS graft (*n* = 34)	Laparoscopic Davydov (*n* = 41)
Age (years)	24.9 ± 3.9 (20–43)	24.8 ± 3.4 (19–35)
Urinary anomaly (*n*)	2	2
Length of vagina before surgery (cm)	0.21 ± 0.59 (0–3)	0.67 ± 1.0 (0–3)
Previous operation (*n*)	0	1
Secondary sexual characteristics:		
Normal (*n*)	34	41
Abnormal (*n*)	0	0
Presence of functional endometrium in the primordial uterus (*n*):		
No functional endometrium	34	39
With functional endometrium	0	2

Data are mean ± SD (range) or *n*.
SIS, acellular porcine small intestinal submucosa.

patient in the SIS group who had bilateral ovarian cysts underwent concomitant laparoscopic ovarian cystectomy. Patients in the Davydov group had significantly more estimated blood loss than those in the SIS group (49.5 ± 25.1 ml versus 18.2 ± 13.3 ml, $P < 0.001$). However, the difference of the change of haemoglobin level between the two groups was not statistically significant (4.8 ± 5.9 g/l versus 8.2 ± 8.9 g/l, $P = 0.063$). Patients in the SIS group had an earlier return of bowel activity, compared with those in the Davydov group (20.1 ± 2.7 h versus 25.6 ± 4.2 h, $P < 0.001$), and an earlier return to work (2.9 ± 1.7 weeks versus 5.5 ± 2.1 weeks, $P < 0.001$). No statistically significant ($P > 0.05$) differences in post-operative morbidity or length of hospital stay, post-surgery, were noted between the two groups. The operation cost of the Davydove group was only slightly higher than that of the SIS group, and the difference was not statistically significant ($P > 0.05$). This is because that in China, the operation cost depends on the name of the procedure and instruments used, and is not associated with the operation time. However, the total cost was significantly higher in the SIS group than in the Davydov group ($5485.6 ± 778.2 versus $2014.4 ± 292.7, $P < 0.001$), due to the cost ($3525 per graft) of the SIS graft.

Anatomical outcomes

All patients returned for follow-up examinations at 1–3 months after their operation. In the SIS group, vault granulation was observed in 100% of patients at 2 months post-surgery, and then squamous epithelialisation of the neovagina gradually developed from the lower part to the top of vagina (Fig. 2), and ceased at 3–6 months post-surgery. Thus, most patients were advised to stop wearing the mould continuously, but to wear it for 1 h daily, until they had sexual activity at least twice a week. At the beginning of this study, some patients wore the mould continuously for 8–14 months, but no further epithelialisation towards the vault was

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Table II **Perioperative data of the two groups.**

Parameter	Vaginoplasty using SIS graft ($n = 34$)	Laparoscopic Davydov ($n = 41$)	P-value
Operating time (minutes)	30.2 ± 5.2 (20–45)	118.5 ± 43.3 (60–215)	<0.001
Concomitant procedures			
Ovarian cystectomy	1	0	
Excision of the rudimentary horn	0	2	
Estimated blood loss (ml)	18.2 ± 13.3 (5–50)	49.5 ± 25.1 (10–120)	<0.001
Haemoglobin change (g/l)	4.8 ± 5.9 (0–20)	8.2 ± 8.9 (0–40)	0.063
Return of bowel activity (hours)	20.1 ± 2.7 (16–26)	25.6 ± 4.2 (18–36)	<0.001
Post-operative morbidity	30.3% (10/34)	31.7% (13/41)	0.897[a]
Return to work (weeks)	2.9 ± 1.7 (2–6)	5.5 ± 2.1 (3–10)	<0.001
Hospital stay post-surgery (days)	10.7 ± 2.1 (7–15)	11.7 ± 3.1 (6–20)	0.104
Complications	0	0	
Transfusion	0	0	
Operation cost ($)	701 ± 61 (595–802)	952 ± 215 (525–1228)	0.120
Total cost ($)	5486 ± 778 (4813–7737)	2014 ± 293 (1499–2719)	<0.001

Data are mean ± SD (range) or *n*.
SIS, acellular porcine small intestinal submucosa.
[a]Fisher's exact test.

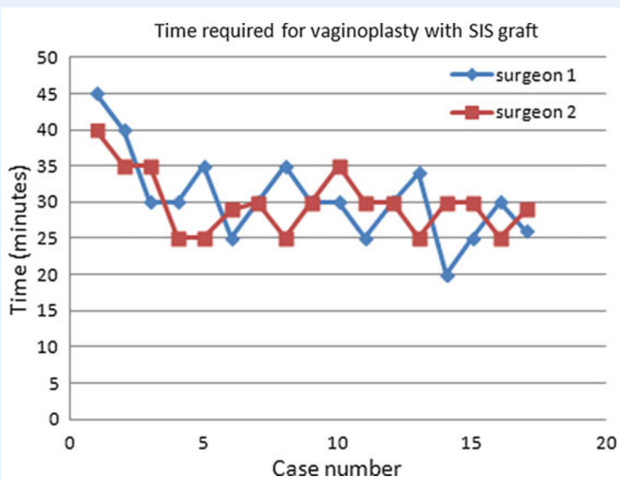

Figure 1 Time required for vaginoplasty using SIS graft as a function of experience.

observed after 6 months post-surgery. After continuous mould wearing was discontinued, the unepithelialised upper neovagina was found to be occluded, with neovagina shortening.

In contrast, vault granulation was observed in only 21.6% (8/37) of patients in the Davydov group, and all granulation disappeared after 6 months post-surgery.

Most patients (28/34 in the SIS group, and 37/41 in the Davydov group) returned for their follow-up 9 months after the operation (Table III). Normal external genitalia, along with a smooth, moist, soft and elastic vaginal wall with a normal vaginal mucosa, were found from gynaecological examinations in both groups. In all patients, two fingers could be introduced easily into the neovagina. The mean length of the neovagina in the Davydov group was slightly longer than that in the SIS group (7.3 ± 1.3 cm versus 6.8 ± 0.9 cm), but the difference was not of statistical significance ($P = 0.081$). If the length of a neovagina of <6 cm was considered to be unsatisfactory for vaginoplasty (Fedele et al., 2000, 2010; Cao et al., 2013), four patients (14.3%) in the SIS group, and three patients (8.1%) in the Davydov group, had a neovagina of <6 cm. If a neovagina of <7 cm was considered to be unsatisfactory for vaginoplasty (Giannesi et al., 2005; Liu et al., 2009), 13 (46.4%) patients in the SIS group, and 11 (29.7.3%) patients in the Davydov group, had an unsatisfactory neovaginal length.

Four patients (14.3%) in the SIS group, and four (10.8%) in the Davydov group, had excessive vaginal discharge. Vaginal discharge cultures were carried out and revealed bacterial infections, for which appropriate antibiotics were prescribed, according to the culture sensitivities.

Functional outcomes

Sixteen (53.3%) of the 34 patients in the SIS group, and 25 (61.0%) of the 41 patients in the Davydov group, subsequently had a sexual partner and became sexually active within 2–12 months after surgery. The average time of mould wearing in the SIS group was significantly longer than that in the Davydov group (7.8 ± 3.3 versus 4.8 ± 1.6 months, $P = 0.001$).

The results of sexual functional outcomes in patients of the two groups are shown in Table IV. The mean time between surgery and the start of sexual activity in the SIS group and the Davydov group was similar (5.8 ± 2.1 months versus 6.9 ± 2.5 months, $P = 0.152$). There was no statistically significant difference in the total FSFI scores and in the scores of all six domains of the FSFI between the two groups. Four patients in the SIS

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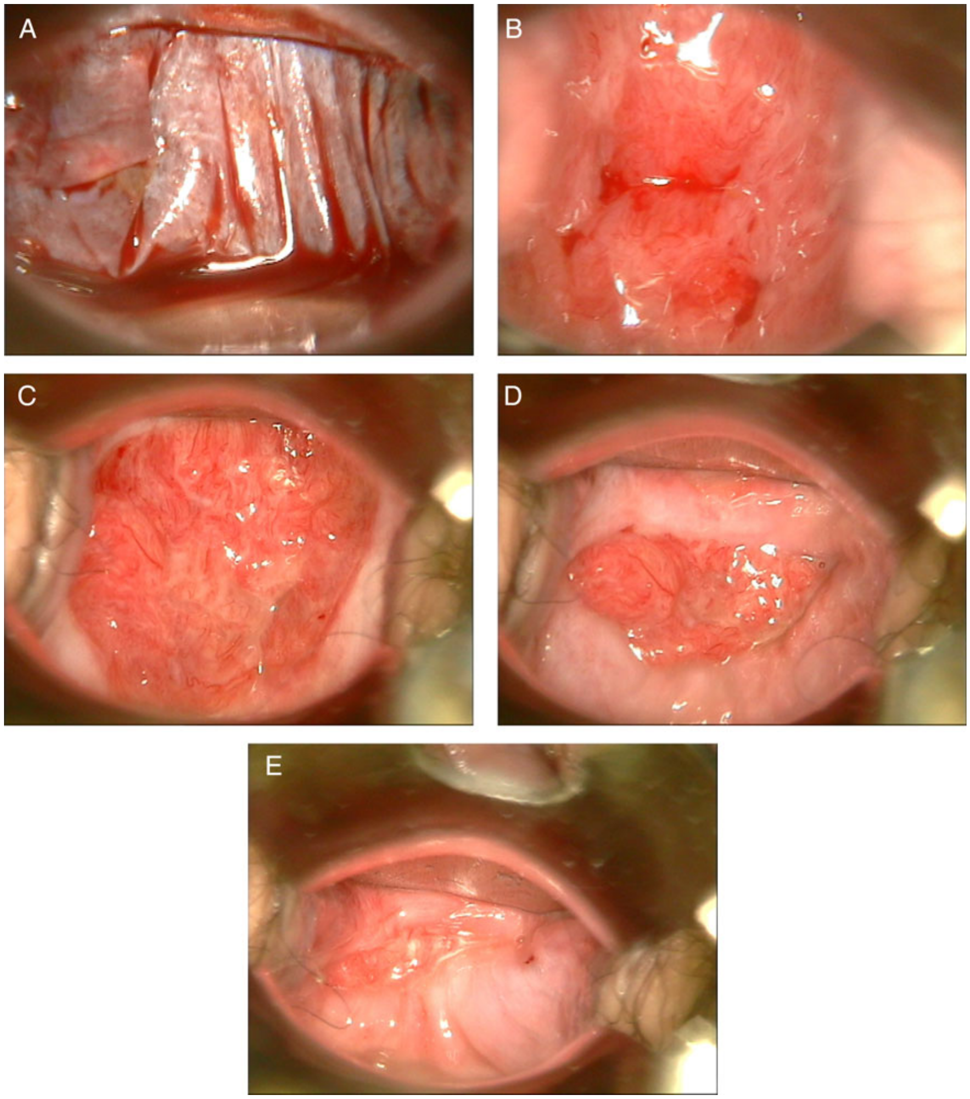

Figure 2 The appearance of the neovagina under colposcopy of the same woman who underwent vaginoplasty using acellular porcine small intestinal submucosa graft at (**A**) 1 week, (**B**) 2 months, (**C**) 4 months, (**D**) 6 months and (**E**) 9 months post-surgery. Original magnification $\times 10$.

group, and six in the Davydov group, reported low total FSFI scores (≤ 23). Among them, three patients in the SIS group, and three in the Davydov group, had a neovagina of <6 cm in length.

In addition, we compared the sexual functional outcomes of the patients and the satisfaction score of the male partner (Table V). The FSFI score of women with a neovaginal length ≥ 6 cm (26.6 ± 2.3 versus 21.5 ± 1.5, $P < 0.001$) and the satisfaction score of their partner (8.6 ± 1.2 versus 6.6 ± 1.2, $P < 0.001$) were both significantly higher than for women with a neovaginal length <6 cm.

Discussion

In this prospective observational study, we reported our successful experiences of vaginoplasty in 34 patients with MRKHS by using SIS graft, and compared the effectiveness and long-term anatomical and functional results of this procedure with laparoscopic peritoneal vaginoplasty. Our findings showed that vaginoplasty using SIS graft caused less trauma, and demonstrated similar anatomical and functional outcomes compared with laparoscopic peritoneal vaginoplasty. However, patients in the SIS group wore the vaginal mould for a longer period, and the length of the neovagina was slightly shorter, when compared with the Davydov group.

The treatment of MRKHS poses a technical challenge because its outcome may affect the patients' physical health, as well as their psychological and emotional well-being. The goal is to reconstruct a canal of appropriate axial direction and adequate size situated between the bladder and rectum, also with normal lubrication when sexually aroused, to permit sexual intercourse. Ideally, a successful treatment should construct a neovagina that requires minimal, if any, dilation, free from scars, stenosis, or contracture and provides a satisfactory cosmetic appearance with intact external genitalia. Above all, it should allow the patient to perform sexual activity satisfactorily.

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Table III **Characteristics and results of anatomical outcomes in patients with Mayer–Rokitansky–Küster–Hauser syndrome (MRKHS) who underwent vaginoplasty using acellular porcine small intestinal submucosa (SIS) graft when compared with those who underwent laparoscopic Davydov vaginoplasty.**

Parameter	Vaginoplasty using SIS graft (*n* = 28)	Laparoscopic Davydov (*n* = 37)	*P*-value
Length of the neovagina (cm)	6.8 ± 0.9 (5–8.5)	7.3 ± 1.3 (5–9)	0.081
Neovaginal length <7 cm	13 (46)	11 (30)	
Neovaginal length ≥7 cm	15 (54)	26 (70)	0.201[a]
Neovaginal length ≥6 cm	24 (86)	34 (92)	
Insufficient vaginal length (<6 cm)	4 (14)	3 (8)	0.453[a]

Data are mean ± SD (range) or *n* (%).
[a]Fisher's exact test.

Table IV **Results of sexual functional outcomes in patients with Mayer–Rokitansky–Küster–Hauser syndrome (MRKHS) who underwent vaginoplasty using acellular porcine small intestinal submucosa (SIS) graft when compared with those who underwent laparoscopic Davydov vaginoplasty.**

Parameter	Vaginoplasty using SIS graft (*n* = 16)	Laparoscopic Davydov (*n* = 25)	*P*-value
Mean time between surgery and the start of sexual activity (months)	5.8 ± 2.1 (2–11)	6.9 ± 2.5 (2–12)	0.152
Total FSFI score	25.60 ± 3.15	25.78 ± 2.74	0.844
≥30	2	2	0.894[a]
24–29	10	17	
≤23	4	6	
Desire score	3.47 ± 0.55	3.70 ± 0.48	0.170
Arousal score	4.05 ± 0.74	3.97 ± 0.67	0.729
Lubrication score	4.91 ± 0.88	4.73 ± 0.92	0.550
Orgasm score	4.13 ± 0.89	3.87 ± 1.25	0.253
Satisfaction score	4.36 ± 0.54	4.41 ± 0.52	0.791
Comfort score	4.69 ± 1.55	5.10 ± 1.05	0.309
Duration of continuous mould wearing (months)	7.8 ± 3.3 (2–14)	4.8 ± 1.6 (2–8)	0.001

Data are mean ± SD (range) or *n*.
[a]Fisher's exact test.
**P* < 0.05.

In this study, a critical part of the operation in both groups was to find the right anatomical route of the neovagina, whilst avoiding injuries to the bladder, urethra and rectum. To avoid these complications, we made a minor technical modification to the procedure: 300–400 ml of normal saline, containing 2.0 mg of phenylephrine and methylthioninium chloride (blue dye), was injected along the anatomical vaginal route. And a metal urinary drainage tube was inserted into the urethra and bladder to observe whether there was any blue dye coming out from the tube, so the operator could detect any injury to the urethra and bladder immediately. In addition, the rectum was digitally assessed with one finger by the operator to make sure that the rectum was not injured. Hence, this modified technique resulted in no injury in our study patients.

Biological grafts, used in soft tissue repair, are derived through different processes and from distinctly different anatomical locations—human or animal dermis, bovine pericardium, or SIS. Previous reports of vaginoplasty with tissue-engineered biological grafts are rare. Zhu *et al.* (2013) had reported vaginoplasty with acellular dermal matrix (ADM), which had an anatomical success rate of 100% (a vaginal length ≥8 cm and a width allowing the easy introduction of two fingers). We reported two cases of vaginoplasty using SIS graft in 2013 (Ding *et al.*, 2013), and found that the neovagina constructed with this procedure was the same as that of a normal adult vagina histologically and physiologically. And in this study we presented our successful experiences of vaginoplasty in 34 patients with MRKHS by using SIS graft, and compared the effectiveness and long-term anatomic and functional results of this procedure with laparoscopic peritoneal vaginoplasty.

There are also other methods without the use of transplanted tissue, e.g. the Frank technique, the Sheares vaginoplasty and the Vecchietti method. The non-surgical method—the Frank technique—was first reported in 1938 (Frank , 1938), and was modified by Ingram (1981)

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Table V Sexual function of the women and satisfaction score of their spouse in patients with neovaginal length of <6 cm versus ≥6 cm.

Neovaginal length	<6 cm (n = 7)	≥6 cm (n = 34)	P-value
Total FSFI score of the women	21.5 ± 1.5	26.6 ± 2.3	<0.001
≥30	0	4	
24–29	1	26	
≤23	6	4	
Satisfaction score of the male partner	6.6 ± 1.0	8.6 ± 1.2	<0.001

Data are mean ± SD or *n*.

by inserting dilators into the saddle of a bicycle stool and having the patients sit astride this to gently create perineal pressure. High successful rates were reported, and some gynaecologists considered it as the first choice for creation of the vagina in MRKHS (Edmonds *et al.*, 2012). However, the intermittent pressure technique is associated with much discomfort, and the comparison of the FSFI scores of women who used dilators revealed lower overall scores (McQuillan and Grover, 2014). In the initial pilot work by Liao, the possibility that the use of dilators might contribute to a negative body image was raised, with barriers to dilatation being privacy, time, discomfort and the dilators themselves not being female-friendly (Liao, 2006). This negative effect was not reported in women who underwent operative procedures and required the use of a vaginal mould for 3–6 months post-operatively—although this may simply reflect the fact that this has not been explored. Thus many gynaecologists have continued to seek a surgical solution, rather than a non-surgical one.

The surgical methods without the use of transplanted tissue mainly include the Vecchietti method and the Sheares vaginoplasty. Compared with the gradual dilatation technique by Vecchietti (Vecchietti, 1965; Fedele *et al.*, 2000), our method using SIS graft required considerably less time, needed no traction device and caused less patient discomfort. In Sheares vaginoplasty, a perineal skin flap is inserted as an isograft into the space tunnelled between the rectum and bladder, with the Müllerian ducts used for orientation, and is based on the principle of Wharton, stating that epithelialisation of the new tunnel occurs both from the vaginal orifice and the edges of the isografts (Schätz *et al.*, 2005; Chakrabarty *et al.*, 2011; Walch *et al.*, 2011). McQuillan and Grover (2014) summarized the 289 reported cases of Sheares vaginoplasty, the stenosis rate was 1.73% (5/289) and the length of the neovagina was satisfying. In line with the results from our study, Walch *et al.* (2011) reported that in women with a follow-up time of <4 months, the process of epithelialisation was not entirely complete at the cranial end of the neovaginal vault. This might explain why some authors (Chakrabarty *et al.*, 2011) used the amniotic membrane during the Sheares procedure. Hence, this would imply that the long post-operative mould wearing time was also a problem when the Sheares procedure was used.

In the present study, SIS graft was used for the reconstruction of the vagina, and this method was compared with the Davydov procedure. The SIS is derived from the submucosal layer of the porcine small intestine that has been mechanically separated from the adjoining intestinal layers. The SIS is acellular and biocompatible, and it does not produce an immunological rejection response. This sterile, freeze-dried, non-permanent, acellular matrix graft, made from porcine jejunum appears to promote the rapid ingrowth of the surrounding tissue (Jankowski *et al.*, 2004), and epithelialisation of the neovagina is allowed to occur. The SIS graft is commercially readily available, and it is completely biodegradable. In our study, we used a four-layered SIS graft. Compared with the original single-layer SIS, the multi-layer SIS has stronger mechanical properties and is more slowly degraded in wounds (Shi and Ronfard, 2013).

Our results showed that the mean length of the neovagina in the SIS group was 6.8 ± 0.9 cm, and four patients (14.3%) in the SIS group had a neovagina <6 cm long. Considering that women with an artificial vagina, like those with a primary normally structured vagina, experience a functional extension of 2–3 cm during the excitement phase of sexual intercourse (Mobus *et al.*, 1996), a vaginal length of ≥6 cm is required for sexual intercourse to be performed without problems. Therefore, these anatomical results were acceptable.

In our follow-up, granulation tissue was observed at the neovaginal vault after vaginoplasty using SIS graft, followed by the gradual development of squamous epithelialisation of the neovagina from the lower part of the vagina to the top. In most patients, the epithelisation ceased at 3–6 months post-surgery, after which the patients stopped wearing the mould continuously. However, an unepithelialised upper neovagina was observed to be occluded, and the neovagina become shorter. This was the reason why that in our results, the neovaginal length was shorter. In Zhu *et al.*'s report, a silicone vaginal dilator was also recommended for use in the first 3–6 months post-operatively to prevent the contraction of the neovagina. At the 3-month follow-up, similar to our results, the vault of the neovagina was also unepithelialised. They also reported that, post-operatively, granulomatous polyps occurred in 6/53 patients (11.3%) at the vaginal vault, which were removed in an outpatient clinic. In our follow-up, we did not find any granulomatous polyps that needed surgery. These differences might be attributed to the difference in the materials used. Our results showed that the mean total FSFI score after vaginoplasty using SIS graft was 25.60 ± 3.15, which was comparable to that of Zhu *et al.*'s results (26.7 ± 3.5) after vaginoplasty using ADM graft.

Laparoscopic peritoneal vaginoplasty is very popular in China. The peritoneum has a great regenerative capacity and can undergo squamous metaplasia when exposed (Soong *et al.*, 2006). Compared with the laparoscopic Davydov procedure, vaginoplasty using SIS graft was less traumatic and avoided abdominal surgery. Our results showed that the operating time was significantly shorter, and the estimated blood loss was significantly less. Patients in the SIS group had an earlier return of bowel activity and an earlier return to work. However, the total cost was significantly higher than that in the Davydov group, due to the cost of the SIS graft. The mean length of the neovagina in the SIS group was slightly shorter than that in the Davydov group, although the difference was not statistically significant (6.8 ± 0.9 cm versus 7.3 ± 1.3 cm, P = 0.081). In addition, there was no statistical difference in the total FSFI scores and in the scores of all six domains of the FSFI between the two groups. These results implied that the vaginoplasty using SIS graft is a safe, effective, minimally invasive technique that provides near normal sexual function to patients with MRKHS, without leaving a scar on the surface of the body and without causing a change of appearance of the vulva.

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Moreover, vault granulation after the Davydov procedure was also reported in previous studies. In a recent study based on 182 patients treated with transvestibular vaginoplasty using pelvic peritoneum, Zhou *et al.* (2010) reported a rate of 18.7% (34/182) for vault granulation. In our study, we found vault granulation in 21.6% (8/37) of patients in the Davydov group. As for amnion vaginoplasty, Tian *et al.* (2007) reported a vault granulation rate of 12.5% (1/8). Compared with these approaches, vaginoplasty using SIS graft presented a 100% rate of vault granulation, and this unepithelialisation of the neovaginal vault lead to a certain rate of unsatisfactory neovaginal length, because of the occlusion of the upper unepithelialised neovagina after the discontinuation of continuous mould wearing. Our results showed that 46.4% (13/28) of the neovaginas were $<$7 cm, and 14.3% (4/28) were $<$6 cm in patients who underwent vaginoplasty with SIS graft.

We also used the FSFI, a standardized international questionnaire to investigate the sexual results and psychometric properties of the patients. The average total FSFI score was not statistically significantly different between the patients who underwent vaginoplasty using SIS graft and those who had peritoneal vaginoplasty. Similarly, no statistically significant difference was found in the six specific FSFI items assessed, including both objective sensations (lubrication and comfort/pain) and subjective feelings (sexual desire, arousal, orgasm and satisfaction).

The total FSFI scores in our laparoscopic Davydov groups are comparable with some of the previous studies using the Davydov procedure (Giannesi *et al.*, 2005; Liu *et al.*, 2009), but are lower than those that Fedele *et al.* (2008) reported. Differences in patients' age, race and culture might account for the difference.

Previous study showed that among the various kinds of vaginoplasty, the Davydov vaginoplasty has a higher average FSFI score than both the bowel vaginoplasty technique in one RCT and the Vecchietti method in a prospective assessment (McQuillan and Grover, 2014). This would explain why the Davydov procedure is among the most popular vaginoplasty methods and is widely used throughout the world.

Furthermore, the study of Liu (Liu *et al.*, 2009) found that the laparoscopic Davydov procedure yields satisfactory anatomical and sexual outcomes, and that the surgery enables women with MRKHS to have a normal sex life that is comparable with a sample of healthy, age-matched women. Thus, in our study, the functional results of the vaginoplasty with SIS graft proved satisfactory, since they were comparable with the Davydov procedure. However, patients in the SIS group wore the mould for a longer period post-surgery, which led to more inconvenience in their daily life.

The vaginal length is one of the determinants of women's overall sexual satisfaction. Liu *et al.*'s study (Liu *et al.*, 2009) found that a shorter neovaginal length ($<$7 cm) appears to be associated with lower total FSFI scores, although the association did not reach statistical significance. Our results found that, in the patients with a neovaginal length $\geq$6 cm, the FSFI score of the women and the satisfaction score of their male partner were both significantly higher than those with a neovaginal length $<$6 cm ($P = 0.000$). This indicates that the satisfaction of the male partner of the patients also seemed also to be associated with the length of the neovagina.

The main limitation of this study is that it is non-randomized. Further randomized studies are warranted to compare the effects of the two procedures. Another limitation is that our study only compared the effects of two methods—vaginoplasty using SIS graft and the Davydov procedure. Thus, further studies might include comparisons among a greater range of methods. Furthermore, psychological well-being may be related to the outcome, e.g. feelings of depression and insecurity, as well as adjustment to the diagnosis MRKHS, may have an influence on the grade of sexual satisfaction (Bean *et al.*, 2009). This represents another weakness of our study, in that our patients were not screened or monitored by a psychologist for mental health problems.

In summary, the vaginoplasty using SIS graft caused less trauma, and provided similar anatomical and functional results to laparoscopic peritoneal vaginoplasty. However, the patients in the SIS group wore the mould for a longer period of time, and the length of the neovagina was slightly shorter (hence, unsatisfactory), when compared with the Davydov group.

Authors' roles

K.H. designed the study, performed the surgical procedures and reviewed the manuscript. J.D. performed the surgical procedures, reviewed the cases, followed the patients and wrote the manuscript, including the figures and tables. L.C. reviewed the literature, followed the patients, performed data collection and analyses, and reviewed the manuscript. X.Zh. and Y.Zh. jointly performed the surgical procedures, jointly analysed the results and reviewed the manuscript.

Funding

This study was supported by the Chinese National Nature Sciences Foundation (grant number 81471416) and the National Key Clinical Faculty Construction Program of China.

Conflict of interest

None declared.

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