Original Article A new surgical method for penile girth enhancement

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Abstract: Objective: We developed a new surgical model of penile girth enhancement in dog, with minimal damage, fewer complications, and high success rate, to enable the experimental investigation of penile implants. Methods: We obtained materials for penile girth enhancement by processing the pericardium and blood vessel wall collected from pigs. Incisions were made at the penile bulb for the implantation of the materials, and facilitate observation and data collection, based on the anatomical features of dog's penis. We measured the girth of the flaccid penis before and after the operation, and erectile function at 1-month postoperation. In addition to evaluation of recovery from the incision and local pathological changes, ultrasonic examination was performed to monitor the long-term changes associated with implantation. Results: The mean girth of the flaccid penis significantly increased from 7.37±0.40 cm before the operation, to 8.70±0.56 cm postoperation. Dogs resumed normal mating at 1 month after the operation, without any significant change in the mating time. Ultrasonic examination clearly illustrated the implants, and helped in the measurement of the distance between the materials and the baculum. Conclusion: Chinese Rural dog is a promising animal model for penile girth enhancement surgery. The findings demonstrated that surgical implantation into penile bulb was associated with less damage, faster postoperative recovery, and higher success. For the first time, ultrasonic examination provided objective data on the surgical outcomes of penile girth enhancement.

Keywords: Penis, penile girth enhancement, model, biomaterial, ultrasound

Introduction

Penile girth enhancement is designed to improve the function and appearance of penis, enhance the sexual function and alleviate sex-related psychological pressure. However, no standard surgical guidelines are available. In addition, the procedure is controversial and raises ethical issues. Concomitant with social advancement, as people's sexual awareness and needs increase, clinicians are forced to develop new and effective methods and materials. Penile girth enhancement using silicone [1-3] and liquid paraffin injections [3-6] has been associated with complications such as fat liquefaction, granulomatous reaction [7], and penile deformity. Currently, autologous fat transplantation is widely used [8], which, unfortunately, is fraught with several complications including fat absorption, scleroma, and mass formation [9]. As the rate of fat absorption is generally very high (up to 70%), clinicians often include a few adjustments before surgery. However, excessive adjustment may result in hypercorrection and affect the outcomes. In addition, repeated injection of autologous fat is required in some cases. Hyaluronic acid and collagen used in facial treatments, have also exploited clinically to enhance the penile girth. Despite the advantages of relative safety and ease of injection, their rapid absorption renders them ineffective for long-term use, and requires repeated injection for efficacy [10, 11]. Girth enhancement by implanting local flap derived from saphenous vein to expand the albuginea, is complicated. In addition to cost, the relatively high incidence of postoperative complications is unacceptable [12]. Recently, several biomaterials such as silica membrane have been directly used to enhance penile girth in humans without animal testing. However, several postoperative complications, and additional surgeries to repair the damage are serious limitations. We believe that clinicians should be extremely cautious before utilizing new materials and methods in clinical practice. Evaluation of prod-



Figure 1. Penile girth augmentation surgery.

ucts in animal experiments is very important. However, no well-defined animal model of penile girth enhancement has been developed to date. In the present study, we developed a dog model to evaluate the safety and effectiveness of surgical implants with better biomechanical features for the enhancement of penile girth.

Materials and methods

Animals

We used 6 36-month-old healthy male Chinese Rural dogs (provided by the Laboratory Animal Center of Guanhao Biology Co. Ltd.), with a mean body weight of 19±2 kg. The dogs were lodged individually in cages under natural day/ light cycle and provided with mixed feed. The dogs were randomized into treatment and control groups, with 3 dogs in each group.

Reagents and equipment

Reagents including paraformaldehyde (SIGMA), absolute ethyl alcohol (Guangdong Guanghua Chemical Factory Co., Ltd.), dimethylbenzene (Guangzhou chemical reagent factory), green transparent reagent (Huntz Enterprises, Shanghai), paraffin (Haotian WaxTechnology co., LTD, Taicang, Jiangsu), eosin, hematoxylin, and neutral balsam (BiYunTian Institute of Biotech, Beijing), and pentobarbital sodium were used in the present study. An ultrasound diagnostic apparatus for small organs (LOGIQ e GE Medical systems China Co., LTD.) was also used.

Materials

Mesentery, pericardium, and fatty apron were collected from pigs and processed biotechnologically to remove immunogenicity and viral contamination (Guanhao Biology Co. Ltd., Guangzhou). The materials collected from pigs were processed into membrane- and mass-like structures. Several mass-like structures were placed between two membrane-like structures separately to form the materials for penile girth enhancement. Silicon rubber (from USA) was used in the control group.

Penile girth augmentation surgery

The dogs were fasted and avoided water intake for 6 hours before the operation. After weigh-

Table 1. Penile girth after the operation (n = 3, mean \pm S.D.)

Group	Preoperation	1-month post-	3-month post-	6-month
		operation	operation	postoperation
Control	7.37±0.40	8.70±0.56*	8.77±0.51*	8.73±0.57*
Treatment	7.30±0.20	8.63±0.46*	8.67±0.40*	8.70±0.44*

ing, the dogs were anesthetized using pentobarbital sodium (1 ml/kg) injected intravenously. The perineal skins were shaved, and the dogs were fixed in supine position during surgery. lodophor was used for disinfection of skins in the surgical sites. Sterile towels were placed on the skin, and an incision of 1.5 cm was made along the dorsal midline of the diverticulum preputii, extending its external aperture (Figure 1-1). The penis was exposed, and a tourniquet was used at the base of the penis. The girth of the penile bulb was measured (Figure 1-2), and 2 incisions of about 5 mm were made along the lateral sides of the penile bulb. Blunt separation of the foreskin was performed under the mucosa to form a loop tunnel about 2 cm wide. Due to the presence of plexus vasculosus dorsally, the tunnel was not connected, and the materials were implanted under the mucosa (Figure 1-3). The penile girth was then measured (Figure 1-4). Suture interruption of the incisions was performed with absorbable suture (5-0). The penile girth was measured again and recorded before the tourniquet was loosened, and the penis was replaced into the diverticulum preputii. The dogs were maintained individually after the operation.

Postoperative observation

The penile girth enhancement was successfully accomplished by implanting materials at the root of the penile bulb. Normal mating of the dogs was observed at 1 month after the operation. The incision was observed on day 15 postsurgery. The girth of flaccid penis was measured at 1, 3, and 6 months after operation.

Ultrasonic and anatomic examination

General anesthesia was performed after 3 months postoperation. The implants were examined ultrasonically. In brief, normal saline (NS) was injected into the penile bulb to simulate the erection of the penis. The changes of the implants were examined ultrasonically. In addition, biopsy was also performed to deter-

mine the changes of the materials and adjacent tissues.

Histology Biopsies of the penis were obtained at 3 months postoperation from the surgically implanted dogs, as well as

controls. The biopsies were then fixed, washed, embedded, sectioned, and stained with HE, and then examined under optical microscope for inflammation in the tissues and cells.

Statistical analysis

SPSS17.0 was used for the statistical analysis. Mean and standard deviation (S.D.) was used to describe the quantitative data. One-way ANOVA was used for the comparison of quantitative data with normal distribution, and t-test was used for the comparison between two groups. P < 0.05 was considered statistically significant.

Results

Penile girth postsurgery

The dog recovered from incisions very well 15 days after surgery. No swelling or abnormal secretion was found. No slipping out of the implants was found. The penile girth after the operation was listed in **Table 1**. Statistical analysis showed the postsurgical penile girth was significantly higher than presurgical values.

Ultrasonic findings

Ultrasonic examination clearly displayed the internal structure (including baculum, cavernous body at the penile root, and implanted materials) of the penis. Despite general differences between the ultrasound images and the anatomical structures, ultrasonic examination effectively displayed the soft tissues. Ultrasonic images (Figure 2A) before the injection of NS, showed the baculum (Figure 2A-1), cavernous body at the penile root (Figure 2A-2), and implanted materials (Figure 2A-3). Similarly, baculum (Figure 2B-1), cavernous body at the penile root (Figure 2B-2), implants (Figure **2B**-3), and the accordion-like connection (Figure 2B-4) among the implants were also clearly seen in the ultrasonic images of the cross section at the base of the penis. The black shadow seen in the Figure 2B was caused



Figure 2. A and B. Ultrasonic examinations of the penis.



Figure 3. Histological examinations of the penile tissues 3 months after the penile girth enhancement (A and B, treatment group; C and D, control group. HE staining, ×200).

by osseous tissues blocking the ultrasound. Injection of NS into the penile bulb stimulated erection and allowed the examination of ultrasonic images for the degree of expansion.

Histology studies

Normal squamous epithelium was found in the treatment group (Figure 3A and 3B). However,

granulomas along with mild lymphocytic infiltration (\leq 25/HPF) were found in the underlying corium. In addition, several vascular sinuses were found deep in the corium, along with massive lymphocytic and plasma cell infiltration (26-50/HPF). Implant degradation suggested good compatibility with the surrounding tissues. In contrast, banding distribution of the implant fragments associated with fibrous tis-



Figure 4. A-C. Gross anatomy of enlarged penis.

sue hyperplasia was found in the control group (**Figure 3C** and **3D**). Granulomas were found in the superficial corium layer, along with multifocal lymphocytic infiltration in the tissues with the implants (26 to 50/HPF) and capillary hyperplasia (1 to 5/HPF). The findings suggest that the implanted materials are compatible, and biodegradable. Implants induced the proliferation of normal tissues, and therefore, were better than silicon rubber.

Penis anatomy

We also performed anatomical assessment to elucidate the internal structure of the dog's penis, which might help with additional investigations, and surgical development. Dog's penis differs from human penis structurally except for a tubule-like wrapping in the erect penis. The dog's penis contains significantly more changes in the bulb-like dorsal structure (Figure 4A). The injection of NS stimulated erection similar to physiological erection. Figure 4B illustrates the dorsal median section of the dog's penis, containing a baculum in the middle (Figure 4B-1), structurally similar to the cavernous bodies at the root of human penis. The part near the penis root includes fusiform cavernous body, closely wrapping the central bone (Figure 4B-2). Trabecularism of this tissue suggests a cavernous body, with the distribution and shape holding the clue to substantial enlargement of the penile root. Tissues with a thin layer of trabecularism adjacent to the skin were also found in front of the penis (Figure 4B-3). While the shape of these tissues suggested a cavernous body, observation of the dorsal median section of the penis indicated no connection with the fusiform cavernous body (Figure 4B-2). In addition, these thin cavernous bodies were only distributed under the skin of the front portion of the penis, ruling out any substantial enlargement during erection. The finding was consistent with the morphological changes of the dog's penis during erection. The implants were clearly observed from the dorsal median section (Figure 4B-4). The outer membrane-like structure was found adhering to the adjacent tissues, unlike the chondroid tissues. Observation from the ventral median section (Figure 4C) indicated that the cavernous body of urethra (Figure 4C-2) was just beneath the baculum (Figure 4C-1). The distal cavernous body of the urethra was under the baculum, while the proximal cavernous body was wrapped by the baculum. Very slim cavernous body was also found adjacent to the foreskins (Figure 4C-3), which was connected with the cavernous body found at the dorsal part of the penis (Figure 4B-3).

Outcomes of the penile girth enhancement

Chinese Rural dog's, which are gentler than other species, were selected for the penile girth enhancement surgery. The penile skins are also thicker in these dogs than other dogs, and are easier to separate from the cavernous bodies. These features also render it harder for the implant to slip out. The extension of the external aperture of the diverticulum preputii helps the exposure of the penis, which also facilitated the observation of the penis before, during, and after the operation. Small incisions were made at the penile bulb for the implantation of the materials, which minimized the damage to the soft tissues and help with the recovery. The materials were implanted into the penile bulb, which was more effective than implants into the body of the penis, based on the anatomy of the dog's penis. The significant enlargement of the penile bulb during the erection facilitated the observation and data collection.

Discussion

No satisfactory method has been reported for the enhancement of penile girth to date.

Natural biological tissues [13], biosynthetic materials, and tissue-engineered materials were used previously, with varying degrees of success. For instance, natural biological tissues have good histocompatibility and are very easy to obtain, but the materials are absorbed. Biosynthetic materials are very stable, but reportedly associated with prosthesis exposure and poor penile morphology. Tissue-engineered materials appear to be the best materials for penile girth enhancement; however, the relatively immature technologies and complicated cell cultures [14] limited their practical application. Enhancing penile girth by implanting tissue-engineered materials has been regarded as a research hotspot. However, clinicians should be extremely prudent before implanting any material into penis. The safety and effectiveness of the implants should be investigated before clinical application. It is therefore, very important to choose the animals and the surgical technique.

In the present study, we primarily focused on the development of animal model, which facilitates the ultrasonic evaluation of the safety and effectiveness of implants in penile girth enhancement surgery. In the present study, therefore, the penile bulb instead of the whole penis was chosen for the incision and implantation.

The animals used in the experiments are easily available, with a penis anatomy similar to human. In addition, surgical technique with wide application should be selected for successful data collection. In the present study, Chinese Rural dog was chosen due to several advantages: 1) easy availability at a relatively low price, with anatomical structure similar to human's; 2) larger penis size compared with other dogs, and thicker mucosal wrapping of the cavernous body, relatively easy separation between the two layers of connective tissues, and ensuring that the implants do not easily slip out; 3) very gentle, requiring no anesthesia but only feeder's appeasement for the postoperative observations, thus avoid the injuries induced by anesthetization; and 4) penis with special feature, with two cavernous bodies at the root of the penis, which are separated by the penis from the middle. A baculum of about 10 cm length before the penile septum, which was clearly observed in the ultrasonic examination is a marker to facilitate the investigation of the effects of implants on the cavernous body during erection.

During the operation, the clinicians should be careful with the following procedures: 1) Extension of the external aperture of the diverticulum preputii to facilitate the penile exposure and the ensuing procedures, and also avoid the irritation to the dog during the postoperative observation and data collection, and thus avoid the application of general anesthesia during the ensuing data collection; 2) Based on the anatomical structure of the dog's penis, the penile body and bulb are composed of cavernous body of penis. However, enlargement of the penile bulb is considerably significant than penile body, which facilitates data collection after the operation, justifying implant injection into the penile bulb; 3) the clinicians should avoid injury to the blood vessels located ventral to the median penile bulb. The loop tunnel is not required to be connected at this position. The materials used in the present study were also shaped as "C", which were flexible enough to accommodate the erection and flaccidity, without interfering with the surgical outcomes o. In addition, avoiding injury to the blood vessel bundle also greatly decreased the risk of bleeding; and 4) the structure of dog's foreskin is similar to mucosa, which lacks elasticity and is relatively fragile. After incision of the foreskin and exposure of the subcutaneous loose connective tissues, blunt dissection by vessel forceps should be performed to avoid damage to cavernous sinus since it is difficult to control bleeding in cavernous sinus, and adversely affects the outcome.

In the present study, several parameters were measured after the operation. First, we measured the penile girth before and after the operation. Penile girth is a key parameter in the surgical enhancement. However, we only measured the flaccid penile girth as our goal was primarily to develop and verify the animal model. Further investigations involving changes of penile girth before and after the simulated erection will be performed in the following study. Second, we investigated the relationship between the implants and adjacent tissues. Anatomical examinations of the penis at 3-month postoperation help us directly in observing the absorption, calcification, and encapsulation of the implanted materials. In the present study, we observed that the mem-

brane-like materials were merged into the adjacent tissues, as well as partially degraded. Thus accordion-like distribution of the masslike materials was found, which increased the mechanical compliance of the implants according to the physiological features of the penis. We will further discuss the combination of different materials in the future studies. Third, we performed histological examination of the penis, which plays an important role in evaluating the safety of biomaterials. In the present study, we observed local inflammation and scar formation. Finally, we performed ultrasonic examination to investigate the safety and effectiveness of the innovative penile girth enhancement, with potential application in the evaluation of other biomaterials.

Disclosure of conflict of interest

None.

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