Int. J. Morphol.,
41(1):264-267, 2023.

Detailed Anatomy of the Corpora-Glans Ligament via the P45 Plastination Method

Anatomía Detallada de los Ligamentos Cuerpo Cavernoso-Glande Mediante el Método de Plastinación P45

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JIANG, W. B.; LI, C.; GILMORE, C.; YU, S. B. & SUI, H. J. Detailed anatomy of the corpora-glans ligament via the P45 plastination method. *Int. J. Morphol., 41(1)*:264-267, 2023.

SUMMARY: The corporo-glans ligament is the ligament connecting the corpus cavernosum and the glans of the penis. The anatomical description of the corporo-glans ligaments shape is still uncertain, this knowledge affects penile reconstructive procedures. The anatomy of the corporo-glans ligament was analyzed and recorded via observing sagittal sections of 10 different penile P45 plastination sections. According to the P45 plastination sections, the corporo-glans junction displayed a fibrous tissue band connecting the distal ends of the two corpus cavernous (CC) with the glans penis (GP). The fibrous band was a round-obtuse shape and ran deep into the glans of the penis and occupied about 2/3 of the whole GP. The original end was laid in a socket embedded in the GP. The density of the fibers of the ligament at the original end close to the tunica albuginea was less than that of the other parts. The fibers originating from the tunica albuginea, directly extended to the blind end of the two CC, covering the distal end of the two CC.

KEY WORDS: Corpus cavernosus; Corpus spongiosum; Glans penis; Penile reconstruction.

INTRODUCTION

The male genital organ is composed of three erectile cylinders: the bilateral corpus cavernosus (CC) and the underlying corpus spongiosum (CS) (Hsu, 2006; Sam & LaGrange, 2022). The bilateral corpus cavernous (CC) run side by side and together with the underlying corpus spongiosum, form the body of the penis (Fujisawa *et al*., 2008; Sam & LaGrange, 2022). The top of the CC is covered with glans cap (Hsieh *et al*., 2012; Kureel *et al*., 2015). The CS and the two CC are surrounded by tunica albuginea (TA) (Shafik *et al*., 2004). It is reported that there is connective tissue between the cavernous body and the glans of the penis, which is called the corporo-glans ligament (Shafik *et al*., 2004). The mechanism of penile erection involves hemodynamics and is a complex physiological process. Penile erection heavily depends on the integrity of the penile tissue (Andrade *et al*., 2012). Besides vascular problems, other pathologic mechanisms could play a significant role in erectile dysfunction (Moreland, 2000; Gou *et al*., 2022). An understanding of the elastic fibers system in the penis would improve the basic scientific knowledge of the composition and organization of the penis structures that play a key role in the mechanism of erection (Andrade *et al*., 2012; Sam & LaGrange, 2022). The anatomical description of the corporo-glans ligaments shape is still unclear. Only by accurately understanding the fibrous framework of penile erectile tissue can we understand the pathophysiology of human penis. Thus enhancing penile reconstructive techniques and ensuring better patient outcomes (Lee *et al*., 2019). Limited by the existing techniques, the observation of the overall distribution of corporo-glans ligaments within the penis has not been reported. The purpose of this study was to determine in detail the shape of the corporo-glans ligament structure around the distal urethra of the human penis by P45 plastination method.

Ethics Statement. This study was approved by the ethics committee of the Body and Organs Donation Center of Dalian Medical University. The research involved 10 human penis specimens of Chinese adults from the Body and Organs Donation Center. Written informed consent was obtained from the donors involved in this study prior to death in accordance with the regulation of the ethics committee.

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Received: 2022-09-02 Accepted: 2022-12-10

MATERIAL AND METHOD

P45 plastination slice technology: The sagittal P45 sections of 10 cases of the human penis were observed and the anatomical characteristics of the corporo-glans ligament were analyzed and recorded. None of the specimens showed signs of hypospadia or penile cancer. The experimental steps are as follows (Sui & Henry, 2007):

1. Slice: The specimens were frozen at -70 ºC for 2 weeks, embedded in the embedding box by polyurethane, frozen again at -70 ºC for 2 days and sliced with a high-speed band saw to a thickness of 3 mm.

2. Bleaching: Rinsed slices with cold water overnight and soaked in 5 % hydrogen peroxide overnight.

3. Dehydration: After the slice bleaching, the slices were precooled and then dehydrated in 85 % acetone at -25 ºC for 5 days, then placed in 90 % acetone at -15 ºC for 5 days, then degreased at room temperature and finally placed in 100 % acetone.

4. Vacuum impregnation: The slices were taken out from the acetone bath, clamped with a double glass plate, the slice infiltration mold was made, and the slices were filled with Hoffen polyester P45 (Dalian Hoffen Biotechnic Co., Ltd., Dalian, China). The mold filled with the infiltration and embedding material was placed vertically in the vacuum cabinet for impregnation at room temperature. The pressure was slowly reduced to 20, 10, 5 and 0 mmHg according to the bubble size and releasing rate. Keeping the pressure 0 mm Hg until the bubbling stopped. The impregnation time lasted more than 8 hours.

5. Curing: After releasing the vacuum, check and remove the bubbles in the plate. Then the slices were put in a 40 ºC hot water bath and placed upright for 3 days. After curing, the slices were removed from the glass plate and properly covered with bonded plastic folia to provide protection.

6. Observation and photography: The slices were observed under a microscope and photos were taken with a Canon 7D camera (Canon Inc. Tokyo, Japan) camera.

RESULTS

P45 Sagittal sections of human penis: The bilateral CC ended blindly under the cover of the glans of the penis, the distal elongations of the tunica albuginea surrounding the CC pierced the spongiosum part of the glans penis. The P45 plastination sections of 10 cases of human penis, the corporo-glans junction showed the presence of a fibrous tissue band which connected the distal blind ends of the two CC with the GP (Fig. 1). The corporal end lay in a socket embedded in the GP (Fig. 1). Around the blind end of the CC, the fibers originated from the tunica albuginea and finally covered the distal end of the two CC (Fig. 2). The fibers originating from the TA, which ran in a ring shape to the distal end of glans, inserted into the distal of the GP at an round and obtuse and became part of the GP (Fig. 1). The fibers originating from inside of the TA, the fibrous band occupied roughly 1/3 of the GP, the fibers originating from outside of the TA, occupied about 2/3 of the GP. It was found that the TA at the blind end was thinner than the TA around the body of CC (Fig. 2). The lateral margins of the band merged with the cavernous tissue of the GP. The fibers originating from the TA ran into the distal part of the GP, where it sent out fibers that were continuous with the fibrous septa between the sinusoids of the cavernous tissue of the GP (Fig. 2). In addition, a relation could not be observed between the corporo-glans ligament and the structures located in the dorsal aspect (superficial and deep dorsal veins, deep arteries, and nerves) of the penis in this study.

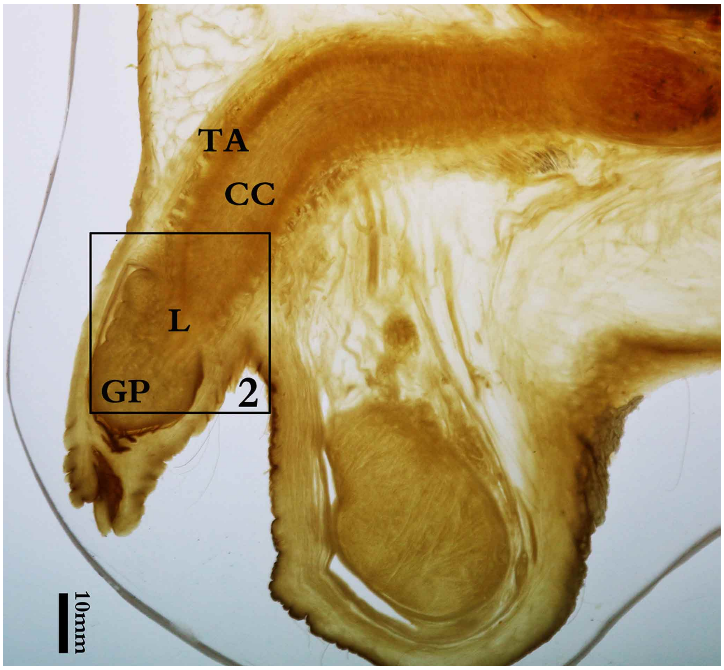

Fig. 1. Median sagittal P45 plastination section of human penis. CC: corpus cavernosus, GP: glans penis, TA: tunica albuginea, L: corporo-glans ligament. The fibers originating from the TA, which were ring shape to the distal end of glans, insert into the distal of the GP at an round and obtuse and became part of the GP.

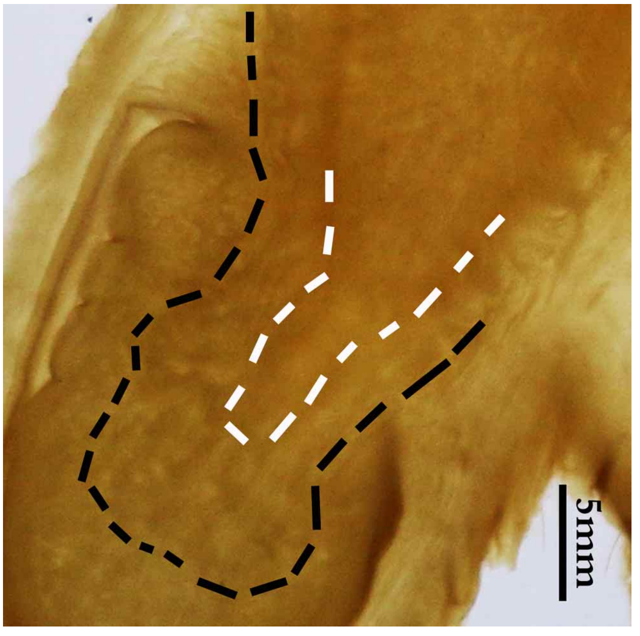

Fig. 2. Enlargement of 2 in figure 1. Black dotted line: the outside boundaries of corporo-glans ligament; White dotted line: the inside boundaries of corporo-glans ligament; The corporo-glans ligament of the penis was embedded in the glans, and is round and obtuse in shape; the ligament originated from the TA, and terminated at the lower third of the GP; the density of the fibers of the ligament at the original end close to the TA were lower than that of the other parts.

DISCUSSION

The penile erective process requires the support of a group of complex structures which are closely related to the distribution of the fibrous connective tissue, consisting of mainly elastic fibers and bundles of collagen, which make the penis extensible (Hsieh *et al*., 2020). The function of the penis is also dependent on the fibers of the elastic system (Liu *et al*., 1993; Costa *et al*., 2006; Chen *et al*., 2017). Understanding the anatomical information of the elastic fibers in the penis would undoubtedly allow us to have a better treatment procedure of the erectile dysfunction (Qiao *et al*., 2017).

The penis consists of two CC and one CS. The CC was supported by a fibrous skeleton, in most animals, including the tunica albuginea, the inner column of the cavernous body, the fibrous network of the cavernous body and the fibrous sheath around the artery and nerve (Sam & LaGrange, 2022). The functions of the sponge frame were seemed to significantly increased the strength of TA (Goldstein & Padma-Nathan, 1990). The fibrous sheath of the body merges the three parts as a unit during erection and penile propulsion (Tamaki, 1992). Compared with the TA of the CC, the TA of the cavernous body deep in the glans was thinner and less tough (Shafik *et al*., 2004). The distal ends of the two CC were embedded in one of the sockets of the GP (Goldstein *et al*., 1982). During erection, two CC and the corpus spongiosum were congested including GP. During penile thrusting, the rigid corporal ends embedded in GP act to push the glans forward into the vagina. They allow for rigidity for the soft congested GP during vaginal penetration and penile thrusting (Shirai *et al*., 1978; Özbey & Morozov, 2021). Although the fibers were giving elasticity to the connective tissue of the glans, there was no detailed description of the fibers in GP.

In the past, due to the limitation of technical barriers, the structural information about the fiber of corporo-glans ligament was limited. In this study, the observation about the adjacent relationships between the soft tissue and the neighboring structures were rediged by using application of P45 plastination technique. It was found that the corporo-glans ligament seems to be a direct extension of TA. The fibers at the blind end of the ligament formed a circular obtuse fibrous structure with the septum of the sinus fibers in GP, which seems to provide a firm connection between the blind end of the ligament and the GP. This study was similar to previous studies (Shafik *et al*., 2004; Lee *et al*., 2019). Based on this result, it is speculated that the main function of the ligament may be to provide a strong connection between the distal end of GP and the two CC, especially during penile propulsion. Furthermore, it has been proposed that this anatomical structure was useful for hypospadias repair (Özbey & Etker, 2017).

In the process of erection and sexual intercourse, elastic fiber systems play an important role in the firmness of the penile glans. When the elastic fiber decreases, it resists less expansion during the erection process, resulting in a reduction in stress, leading to ED (Barroso Jr. & de Bessa Jr., 2020; Özbey & Morozov, 2021). Therefore, the description of the fibers inside the GP in this study should be noted by clinicians when performing penile reconstruction to restore this anatomical structure.

ACKNOWLEDGMENTS. We would like to thank Director Yun Zheng of Dalian Hoffen Biotechnology Co., Ltd., for assistance with photography.

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RESUMEN: El ligamento cuerpo cavernoso-glande es el ligamento que conecta el cuerpo cavernoso y el glande del pene.

La descripción anatómica de la forma de los ligamentos cuerpo cavernoso -glande aún es incierta; este conocimiento afecta los procedimientos reconstructivos del pene. La anatomía del ligamento cuerpo cavernoso-glande se analizó y registró mediante la observación de 10 secciones sagitales diferentes del pene a través de plastinación P45. Según las secciones de plastinación, la unión cuerpo-glande mostraba una banda de tejido fibroso que conectaba los extremos distales de los dos cuerpos cavernosos con el glande del pene. La banda fibrosa tenía una forma redonda y obtusa y se adentraba profundamente en el glande del pene ocupando alrededor de 2/3 de él. En su origen se coloca en un espacio profundo en el glande del pene. La densidad de las fibras del ligamento cuerpo cavernoso-glande en su origen cercano a la túnica albugínea era menor que el de las otras partes. Las fibras que se originan en la túnica albugínea, se extienden directamente hasta el extremo ciego de los dos cuerpos cavernosos, cubriendo el extremo distal de estos.

PALABRAS CLAVE: Cuerpo cavernoso; Cuerpo esponjoso; Glande del pene; Reconstrucción peneana.

REFERENCES

Andrade, F.; Cardoso, G.P.; Bastos, A.L.; Costa, W.; Chagas, M. & Babinski, M. Structural and stereological analysis of elastic fibers in the glans penis of young men. *Rom. J. Morphol. Embryol., 53(2)*:393-6, 2012.

Barroso Jr., U. & de Bessa Jr., J. Letter to the Editor regarding article published: "Erectile dysfunction in patients undergoing multiple attempts at hypospadias repair: Etiologies and concerns" By Husmann DA. *J. Pediatr. Urol., 17(2)*:166.e1-166.e7, 2021.

Chen, X.; Wu, Y.; Tao, L.; Yan, Y.; Pang, J.; Zhang, S. & Li, S. Visualization of penile suspensory ligamentous system based on visible human data sets. *Med. Sci. Monit., 23*:2436-44, 2017.

Costa, W. S.; Carrerete, F. B.; Horta, W. G. & Sampaio, F. J. B. Comparative analysis of the penis corpora cavernosa in controls and patients with erectile dysfunction. *BJU Int., 97(3)*:567-9, 2006.

Fujisawa, Y.; Nakamura, Y.; Takahashi, T.; Kawachi, Y. & Otsuka, F. Penile preservation surgery in a case of extramammary Paget's disease involving the glans penis and distal urethra. *Dermatol. Surg., 34(6)*:823-31, 2008.

Goldstein, A. M. & Padma-Nathan, H. The microarchitecture of the intracavernosal smooth muscle and the cavernosal fibrous skeleton. *J. Urol., 144(5)*:1144-6, 1990.

Goldstein, A. M.; Meehan, J. P.; Zakhary, R.; Buckley, P. A. & Rogers, F. A. New observations on microarchitecture of corpora cavernosa in man and possible relationship to mechanism of erection. *Urology, 20(3)*:259-66, 1982.

Gou, C.; Liu, T. & Chen, Z. Effects of unilateral/bilateral amputation of the ischiocavernosus muscle in male rats on erectile function and conception. *Basic Clin. Androl., 32*:1, 2022.

Hsieh, C. H.; Hsu, G. L.; Chang, S. J.; Yang, S. S.; Liu, S. P. & Hsieh, J. T. Surgical niche for the treatment of erectile dysfunction. *Int. J. Urol., 27(2)*:117-33, 2020.

Hsieh, C. H.; Liu, S. P.; Hsu, G.L.; Chen, H. S.; Molodysky, E.; Chen, Y. H. & Yu, H. J. Advances in understanding of mammalian penile evolution, human penile anatomy and human erection physiology: Clinical implications for physicians and surgeons. *Med. Sci. Monit., 18(7)*:RA118-25, 2012.

Hsu, G. L. Hypothesis of human penile anatomy, erection hemodynamics and their clinical applications. *Asian J. Androl., 8*:225-34, 2006.

Kureel, S. N.; Gupta, A.; Sunil, K.; Dheer, Y.; Kumar, M. & Tomar, V. K. Surgical anatomy of the penis in hypospadias: magnetic resonance imaging study of the tissue planes, vessels, and collaterals. *Urology, 85(5)*:1173-8, 2015.

Lee, S. H.; Ha, T. J.; Koh, K. S. & Song, W. C. Ligamentous structures in human glans penis. *J. Anat., 234(1)*:83-8, 2019.

Liu, L. C.; Huang, C. H.; Huang, Y. L.; Chiang, C. P.; Chou, Y. H.; Liu, L. H.; Shieh, S. R. & Lu, P. S. Ultrastructural features of penile tissue in impotent men. *Br. J. Urol., 72(5 Pt. 1)*:635-42, 1993.

Moreland, R. B. Pathophysiology of erectile dysfunction: the contributions of trabecular structure to function and the role of functional antagonism. *Int. J. Impot. Res., 12 Suppl. 4*:S39-46, 2000.

Özbey, H. & Etker, S¸. Hypospadias repair with the glanular-frenular collar (GFC) technique. *J. Pediatr. Urol., 13(1)*:34.e1-34.e6, 2017.

Özbey, H. & Morozov, D. Hypospadias surgery, erectile dysfunction and the distal ligament. *J. Pediatr. Urol., 17(4)*:592-3, 2021.

Qiao, X. H.; Zhang, J. J.; Gao, F.; Li, F.; Bai, M.; Du, L. F. & Xing, J. F. An experimental study: quantitatively evaluating the change of the content of collagen fibres in penis with two-dimensional ShearWave™ Elastography. *Andrologia, 49(5)*:e12653, 2017.

Sam, P. & LaGrange, C. A. *Anatomy, Abdomen and Pelvis, Penis.* Treasure Island (FL), StatPearls, 2022.

Shafik, A.; Shafik, A.; Asaad, S.; Wahdan, M. & Morris, M. The corporo-glans ligament: description and functional significance of a ligament connecting the corpora cavernosa to the glans penis. *Int. J. Impot. Res., 16(3)*:220-3, 2004.

Shirai, M.; Ishii, N.; Mitsukawa, S.; Matsuda, S. & Nakamura, M. Hemodynamic mechanism of erection in the human penis. *Arch. Androl., 1(4)*:345-9, 1978.

Sui, H. J. & Henry, R. W. Polyester plastination of biological tissue: Hoffen P45 technique. *J. Int. Soc. Plastination., 22*:78-81, 2007.

Tamaki, M. Mechanism preventing backflow from the canine corpora cavernosa to arteries in the rigid phase of penile erection. *Urol. Int., 48(1)*:64-70, 1992.

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