Research Article

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ESTABLISHING NORMAL PENILE SKIN SENSATION USING TWO-POINT DISCRIMINATION TEST

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ABSTRACT

Introductions: To many penile surgeries, degloving of the penis is a routine part. The effect of this on penile sensation is unknown. The Two-Point Discrimination test (TPD) is used in clinical practice to evaluate sensory nerve function. There is no normative data for two-point discrimination sensation in the penile skin in children.

Methods: Participants were prospectively collected from the pediatric surgical clinic patients provided they were: 7 years or older, generally healthy with no known systemic or neurological disease, had no prior genitourinary surgery or trauma, and demonstrated understanding of the test principle on the fingers. Lowest TPD test was recorded for the following areas: dorsum of penis, ventral surface of penis, pubic skin, scrotum and medial thigh. The test was started at 5 mm and incrementally increased by 1-2 mm until the child could reliably feel two separate touch points by giving correct responses 4 out of 5 or 7 out of 10 times for each area. Data was analysed using mean +/- standard deviation.

Results: 24 patients were enrolled during the study period August 2021 - October 2022, mean age 10 +/-2.1 years. TPD for dorsal and ventral penile skin was 8.5 +/-1 mm. For the scrotum, pubic skin and medial thigh; TPD was 9.9 +/-1.6, 10.3 +/-1.8 and 14 +/- 2.4 mm; respectively.

Conclusion: Normal TPD for the penile skin is around 8 mm. This will aid in studying sensory effects of penile surgery, particularly degloving penile skin.

INTRODUCTION

Degloving the penis is a routine part of many pediatric penile surgeries. These include repair of hypospadias, penile torsion, and chordee correction amongst others. The effect of such manoeuvre on the sensation of penile skin has never been established. This is partially because the normal sensation of penile skin has not been objectively assessed. Degloving, whether due to accidental (1), or surgical (2) trauma, can lead to effects on sensation and potentially, sexual function. TPDT measures innervation density, i.e. number of nerve endings present in the area tested, and is one of the most commonly used indictors in clinical practice to evaluate sensory nerve function, the severity of nerve injuries and recovery following repair (3, 4), and neuropathy of the peripheral nerve system and the central nervous system (5, 6). It relies on the ability and willingness of the test subject to report what they are feeling and is usually performed with the eyes closed. TPDT has two variations: The Weber test (Static: sTPDT), which evaluates the slowly adapting (SA) sensory fibres (constant touch),and the Moving (dynamic) dTPDT, which evaluates the innervation density of fast adapting (FA) sensory fibres which mediates the perception of the moving touch stimuli (7, 8). We aimed to establish normal penile sensation in children using dTPDT.

MATERIAL AND METHODS

The study was conducted between August 2021 and October 2022. Participants were prospectively collected from the pediatric surgical clinic. Inclusion criteria were as follows: 1. Male child who is 7 years or older, generally healthy, without known systemic or neurological disease. 2. Has no history of genitourinary trauma or prior surgery (except for a standard circumcision), and no current infection in the area of interest. 3. Cooperative and could distinguish two-point discrimination on tip of fingers. The last criterion was added to ensure that the child could comprehend the principles of the test and that the results were a true reflection of the sensation of the examined area.

Initially the child and the family had an introduction to the test. We used a Castroviejo Caliper (figure 1) to apply moving

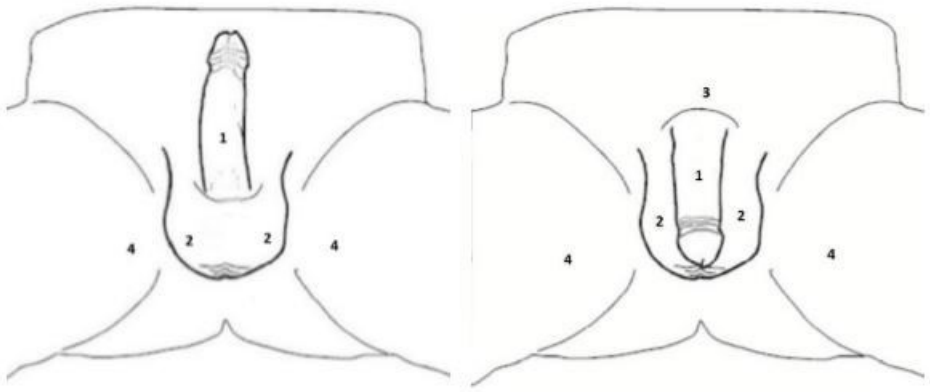
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touch on two adjacent points simultaneously in longitudinal direction from proximal to distal using the weight of the caliper alone. The lowest distance which the child can distinguish between two touch points was recorded for the following areas: dorsum of penis, ventral surface of penis, pubic skin, scrotum, and medial thigh. Tested areas are illustrated in figure 2. The child was asked to report whether one or two points were felt with the eyes closed. The child was positioned on a hard surface and asked to stay immobile throughout the test. The standardized test was started at 5 mm distance and incrementally increased by 1-2 mm until the child could reliably feel two separate touch points by giving correct responses 4 out of 5 or 7 out of 10 times for each area. The reason for starting at 5 mm is that in a pilot study, no child was able to distinguish TPDT in less than 5 mm range. Data was summarised using mean +/- standard deviation.

Figure 1



Figure 2



RESULTS

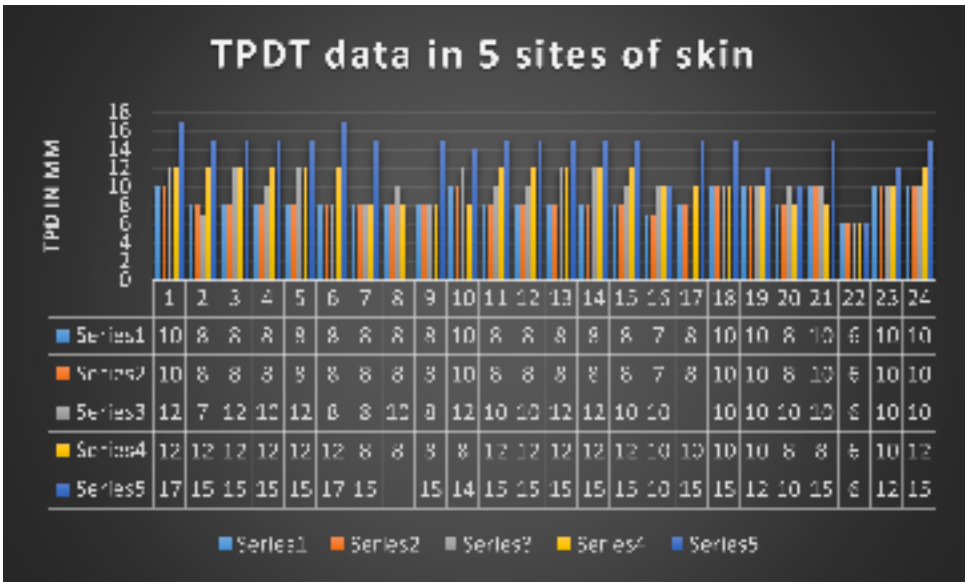
29 subjects were initially approached and 5 were excluded as they could not reliably pass the test on the fingertips. 24 patients were enrolled, of which only 2 are uncircumcised. The mean age was 10 +/-2.1 years. TPDT for dorsal and ventral penile skin was 8.5 +/-1 mm. For the scrotum, pubic skin and medial thigh; TPD was 9.9 +/1.6, 10.3 +/-1.8 and 14 +/- 2.4 mm; respectively. Results are summarised in table 1. Individual test values are listed in table 2

Table 1

Table 1. Mean and SD of TPDT by mm in tested areas.					
	Ventral penile skin	**Dorsal penile skin**	**Scrotal skin**	**Pubic skin**	**Medial thigh skin**
Mean	8.5	8.5	9.9	10.3	14
SD	1	1	1.6	1.8	2.4

Table 2

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DISCUSSION

The skin is our largest sensory organ and across the whole body is innervated by approximately 230,000 tactile afferent fibers. 15% innervate the palmar skin of both hands and 19% the region surrounding the face and lips. Around 60% of all tactile fibers are SA, while the rest are FA (9). Body areas differ both in tactile receptor density and somatosensory cortical representation (10, 11) although innervation density is weakly correlated with the size of this representation (9). However, precise estimates of innervation density are only available for some body parts, such as the hands, and estimates of the total number of tactile afferent fibers are inconsistent and incomplete (9). The major sensory and somatic supply to the penis is derived from the pudendal nerve (S2–4). The pudendal nerve branches to become the dorsal nerve of the penis. The dorsal nerve provides sympathetic plus sensory innervation to the penis The nerve runs next to the dorsal artery and supplies the skin and glans penis also. The root of the penis has innervation from the ilioinguinal nerve (12). The posterior columnmedial lemniscus pathway is responsible for carrying information involving fine discriminative touch. Therefore, sensation can be impaired by damage to this pathway or to a peripheral nerve (13, 14).

TPDT is a reliable method used to assess somatosensory function (15, 16). Advantages of this test is that it is commonly used, non-invasive, can be applied in children from age 6 years and older, and it is relatively easy to perform (17). It is a standard test for assessing the neurological damage when present, particularly after surgeries. For the penis, the most applicable examples are procedures that involve routine degloving of the penile skin, such as correction of hypospadias, penile ventral chordee, torsion and others. TPDT also seems to be affected by sex as women seems to have lower TPDT values than those of men (11). TPDT sensitivity also increases with increasing age (11, 17). Normal TPDT for children is 1 mm on the tongue, 2–6 mm on the tips of fingers, 8–12 mm on the palm, and 40–60 mm on the back (18, 22).

Micturition and sexual potency depend on small fibers of the peripheral system, which also mediate warm and cold sensation. Therefore, tests of these fibers might be more relevant in the clinical setting (23). We opted to use dTPDT, as this has been reported to recover faster after nerve repair and detect two points that are closer together than sTPDT (8). Also, dTPDT responds exclusively to dynamic stimuli; but dTPDT, in addition to dynamic responsiveness, also respond to sustained static skin deformation and stretch (8). It is possible this could renders it more accurate when assessing effects of surgery on penile sensation. However, when tested on the index finger, there was no difference between dynamic and static TPDT values (24). There are currently no data comparing the two tests on the penis. Standardising the amount of force applied between one and two points is critical to the reliability of the test, as it can easily exceed the resolution or sensitivity threshold for normal sensation. Tremendous variance in pressures applied result in poor levels of interrater reliability. This perhaps explains some of the lack of agreement in reporting discriminatory function. Also, the number of correct responses required may vary slightly from examiner to examiner because the absolute values obtained were dependent upon the individual examiner (17). In our study, we resorted to use the weight of the caliper to standardize the amount of force applied.

Penile sensation seems to have direct effect on sexual function. Hao Zhang et al reviewed male genital sensation after spinal cord injury, and found the deficiency of genital sensation makes the tactile stimulation of the penis unable to cause sexual

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arousal, disturbs the normal processes of erection and ejaculation, and decreases sexual desire and satisfaction (25). Bleustein et all evaluated 107 patients by quantitative somatosensory testing, including vibration, pressure, spatial perception and thermal thresholds of the penis. Their results indicated that warm thermal threshold measurements taken at the glans penis can be used alone to assess the neurological status of the penis in terms of predicting the occurrence of erectile dysfunction. They concluded that warm thermal thresholds alone offer a quick, noninvasive accurate method of evaluating penile neuropathy in an office setting (26).

Penile and urogenital surgery can potentially affect penile sensation and function. While circumcision is the most common penile procedure, it does not normally involve degloving of the penis and therefore its effect on penile sensation, if present, are likely minimal. This is likely reflected in the discrepancy in results of studies done to evaluate penile sensation before and after circumcision. Bleustein et al did a comparative analysis using quantitative somatosensory tests (including vibration, pressure, spatial perception, and warm and cold thermal thresholds.) to evaluate penile sensory thresholds on the dorsal midline glans of the penis in neonatally circumcised and uncircumcised men, and they demonstrated that circumcision status does not significantly alter the quantitative somatosensory testing results at the glans penis (27). Their results seem to correlate with those of other authors (28, 29). However, De-Min Yang et al evaluated the effect of circumcision on the glans penis sensitivity by comparing the changes of the glans penis vibrotactile threshold between normal men and patients with simple redundant prepuce and among the patients before and after the operation and found that the glans penis perception sensitivity decreases after circumcision (30).

Correction of penile curvature is another relatively common procedure and would normally involve degloving of the penis. Rajmil et all recorded the threshold for penile thermal and vibratory sensation in adult males before, and 3 months after surgery and concluded that it changed significantly, regardless of whether a ventral or dorsal surgical approach is used (31).

To the best of our knowledge, TPDT of the penis in children has never been assessed. Our study represents the first attempt at establishing normative data in children. The main limitations of this is the small sample size, and it can improve by including a larger number of patients from a wider age range. It could also benefit from incorporating Weber test, and heat and cold sensation into the examination to establish how they correlate with dTPDT in the penis. However, prolonging and complicating the test performed might result in more children failing to complete the test, currently representing 17% of initially recruited patients. It could also benefit from including higher number of patients that are uncircumcised, although in our cultural context this wound be challenging.

In this study, we focused on deducing the normal values of TPD in the mentioned sites to be a basis for other studies that assess the effects of penile surgery and degloving of the penis on sensation. We did not do TPDT of glans because the glans innervation should not be affected by degloving the penis, and it is not accessible in children with tight phimosis, and because it can be quite uncomfortable for the child, which might affect cooperation to the degree rendering the test impossible to complete.

CONCLUSION

Degloving of the penis is a routine part of many penile surgeries. The effect of this on penile sensation is unknown. Our study represents the first reported normative data for two-point discrimination sensation in the penile skin in children. This should be useful when assessing the long-term effects of various commonly used surgical manoeuvres.

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