

Original Article

## Relation of Obturator Nerve to Selected Perineal Surgical Procedures in a South African Population

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### HIGHLIGHTS

- The study investigates risk in the treatment of stress urinary incontinence in a South African population during TOT procedures as it is based on European standards.
- It is necessary to note that anatomical variations play a role in the outcome and success of these SUI procedures in South Africans.

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### Introduction

Several methods treating stress urinary incontinence (SUI) may cause hurt to the obturator nerve or its branches. These procedures use the obturator foramen as a way for placing Trans obturator slings. Bauer et al., (2005) introduced the TOT inside-out procedure for treating SUI in men. This procedure uses differently sized and shaped needles from those used in treating SUI in women.

### ABSTRACT

#### Introduction

This study estimates a secure route for the needles via the obturator foramen. The therapy of stress urinary incontinence (SUI) is done by using needles to secure a mesh around the urethra. These procedures use the obturator foramen as a pathway for placing a trans obturator sling. However, the needles are not catered to the South African population and, together with variability in pelvic osteology, may pose a threat to the obturator nerve. The purpose of the study is thus to suggest the safest route for the insertion of transobturator tape without endangerment of the obturator nerve.

#### Methods

After placement of the tapes, the right medial compartment of 14 females and 14 males were dissected. Measurements were taken between landmarks of the obturator region, mesh, and obturator nerve.

#### Results

It was found that the average distance between the mesh and the posterior branch of the obturator nerve (PBON) in the male transobturator tape (TOT) inside-out procedure was 15.32mm, 21.49mm in the female transobturator tape (TOT) outside-in and 13.73mm in the tension-free vaginal tape-obturator (TVT-O) inside-out procedures. As reported by clinicians, the distances were found to be half of the suggested safe distances.

#### Conclusions

The findings may be attributed to the South African population's differences in body size and pelvic osteology. A suggested safe route for the passage of the needles is inferior to the most medial point of the obturator foramen and closer to the lateral border of the ischiopubic ramus. We suggested standardization of these needles for a South African population.

**Keywords:** Male Transobturator Sling; Obturator Nerve; Transobturator Tape

One of the most common surgical methods for treating SUI in females is the tension-free vaginal tape (TVT) procedure described in the mid-1990s (1). Although studies have shown a high curing rate (2, 3), this retro pubic approach is associated with several peri and postoperative complications (4-6). To overcome the complications of the TVT procedure, the transobturator tape (TOT) outside-in procedure was designed by Delorme in 2001 (7). In this procedure,

the tape is introduced via incisions in genitofemoral fold, passing via the obturator foramen and exiting the mid-urethra from the outside to the inside, sparing the retropubic space (8, 9). This procedure has been used for the therapy of SUI in both genders (3, 10). The tension-free vaginal tape-obturator (TVT-O) inside-out procedure was developed by De Leval in 2003 to modify the TOT outside-in technique. The TVT-O procedure uses an inside-out approach by introducing the needles through the obturator foramen from inside to outside (3, 8, 11, 12). Although it has been effectively used for the therapy of woman SUI, it presents with its complications (9).

Several cases have been reported regarding the safety of the procedures for the obturator nerve and its branches (3, 13, 14). The risk of injury to the obturator nerve and its main branches has been suggested by several studies (3, 15, 16). Whiteside and Walters (2004) determined the relationship of the transobturator sling to the anatomical structures in the obturator region of female cadavers. They found that the transobturator sling was, on average, 2.4cm from the obturator canal and concluded that the device poses a slight risk to the obturator nerve (16). Reisenauer et al., (2006) reported similar results. (17).

Various researchers compared the relationship of the inside-out and outside-in approaches to anatomical structures in the obturator foramen (15, 16, 18-22). Ahtari et al., (2006) placed the TVT, TVT-O, and TOT procedures in 10 embalmed female hemipelvises. It was found that the TVT-O tape came closer to the obturator canal when compared to the TOT procedure (18) and other researchers reported similar findings with the inside-out procedures for females being closer to the obturator canal and further from the ischiopubic ramus compared to the outside-in approach (15, 20-22). It has been found that the PBON is at risk during the inside-out procedure (21). It is important to note that needles are developed based on the pelvic dimensions of European populations, using European and American results as the golden standard (7, 11, 23). However, no standards or population-specific needles have been developed for the population of South Africa. This study estimates a safe route for the needles via the obturator foramen in South African people. This paper was conducted at the Department of Anatomy, Faculty of Health Sciences, the University of Pretoria, from January 2012 to December 2015.

### Methods

Before embalming, 28 cadavers from the Anatomy Department, School of Medicine, Faculty of Health Sciences, University of Pretoria received the Trans obturator (TOT) or tension-free vaginal tape-obturator (TVT-O) procedures. This paper was approved by Ethics Committee of the University of Pretoria (74-2013).

The sample consisted of 14 men, who all received the TOT inside-out procedure, and 14 women, where 7

received the TOT outside-in procedure and the remaining 7 the TVT-O inside-out procedure. Before the methods were done, the cadavers were placed in supine lithotomy. The cadaver is placed on its back, and the legs are lifted and placed on stirrups. In this position, the hip is flexed at an angle no less than 100°.

A registered, practicing, experienced urologist performed the procedures at the University. The surgeon performed the TOT and TVT-O procedures. The TOT inside-out procedure in males and the TOT outside-in procedure, and TVT-O inside-out procedures in females were performed according to the literature (23).

After embalming, the cadavers were placed in a supine position with the legs abducted, a modified lithotomy position. Dissection was performed ipsilaterally on the right obturator area (medial thigh and medial compartment of the thigh) to visualize the course of the obturator nerve, measure the distances between its branches, and identify the distances between its branches landmarks.

Initially, observations were made to determine the course of the mesh, as it varied between cadavers concerning which muscles it pierced and where the mesh exited the thigh. The adductor longus muscle was reflected inferiorly from its origin, leaving the tendon intact at its origin to be used as a landmark. By reflecting this muscle, anterior branch of the obturator nerve could be visualized as it coursed between the adductor longus and the adductor brevis muscles. Once located, its relationship to the mesh was observed. It was established that the anterior branch was not at risk during the procedures as it was located far from the placed mesh. Measurements to this branch were thus excluded.

To expose the posterior branch and mesh, the bulk of the adductor brevis muscle was eliminated. The muscle fibers of the adductor brevis and longus were preserved to protect the mesh pathway and avoid damage to the PBON. Measurements were taken as the shortest distance between the nerve and the mesh in the dissection to

**Table 1.** Representation of the landmarks between which measurements were made

<b>A</b>	Obturator Canal
<b>B</b>	Most inferior point of the attachment of adductor longus tendon
<b>C</b>	Mesh
<b>D</b>	Most medial point of the obturator foramen
<b>E</b>	Most inferior point of the pubic symphysis
<b>F</b>	Most inferior point of the obturator foramen
<b>G</b>	Most inferior point of the ischial tuberosity
<b>H</b>	Posterior branch of obturator nerve
<b>I</b>	Junction of the pubis and the ischiopubic ramus



**Figure 1.** The TOT outside-in mesh in a female cadaver in relation to the posterior branch of the obturator nerve. Green=Obturator canal. Blue= point of the shortest distance of the posterior branch to the mesh. Orange=Most medial point of the obturator foramen. Pink=Most inferior point of the obturator foramen

preserve its relations. In all cases, the mesh mostly exited through the gracilis muscle, so the gracilis muscle was not disturbed.

The pectineus and obturator externus muscles were eliminated from their origins to access the obturator canal. Caution was taken not to damage the obturator nerve and its branches as it exited the obturator canal. To access the most medial and most inferior points of the obturator foramen, the adductor magnus muscle was reflected laterally as far as possible. The most inferior point of the pubic symphysis was accessed through the medial reflection of the external genitalia.

Several landmarks were used to describe the association of the mesh to the PBON and its position in the obturator foramen as it passed through the obturator membrane. The landmarks that were established are represented in Table 1. Measurements were taken between these landmarks; refer to Table 2.

## Results

In all dissections for both males and females, it was seen that the mesh pierced the gracilis muscle, which coincides with the trajectory described in other studies (16, 19). Dissection of the obturator region in all males revealed the TOT needle's trajectory and the mesh's location concerning the surrounding anatomical structures. The anterior branch of the obturator nerve was not endangered by the needle, except in one case where the mesh went through the obturator canal. In one case, the PBON is hooked around the mesh and was at risk during the mesh placement in all dissections.

Dissection of the obturator region in seven females revealed the TOT needle's trajectory and the anatomical structures' location. Figure 1 indicates a safe trajectory for TOT outside-in in females. The Figure shows the trajectory of the needle inferior to the medial point of the obturator foramen.



**Figure 2.** Dissection over the obturator area indicating the position of the inside-out (TVT-O) in relation to identified landmarks. Landmarks: Posterior branch of obturator nerve (Blue), Obturator canal (Green), most inferior point of obturator foramen (Red), most medial point of obturator foramen (Orange) and Junction of ischiopubic ramus and the pubis (Purple)

Dissection of the obturator area in females who received the TVT-O inside-out procedure revealed the needle trajectory and the location of the anatomical structures in this region about the mesh (Figure 2). The TVT-O mesh was generally closer to the PBON compared to the TOT outside-in procedure. The posterior branch of the obturator nerve was on average 21.49 mm from the TOT outside-in tape and 13.73 mm from the TVT-O inside-out tape. In one case, it was found to be close to both nerve branches, as the mesh went through the obturator canal. A safe trajectory for the TVT-O needle is shown in Figure 2. The Figure indicates different landmarks in the mesh. The mesh was found running inferior to the most medial point of the obturator foramen, against the lateral border of the ischiopubic ramus.

Basic descriptive statistics were used to determine safe areas for the South African males ( $n=14$ ) and are given in Table 3. All males received the TOT procedure. No statistically significant differences ( $P\text{-value}\leq 0.05$ ), concerning the location of the mesh in the obturator area, were found. On average, the location of the posterior branch of the obturator nerve (H) was 23.31mm from the obturator canal (A) and 40.61mm from the most inferior point of the obturator foramen (F).

A safe area for the trajectory of the needle (C) was determined. Results showed that to be safe, the mesh should be located on average 25.03mm from the obturator canal (A), 36.61mm from the tendon of adductor longus (B), 13.86mm from the most medial point of the obturator foramen (D), 29.98mm from the most inferior point of the pubic symphysis (E) and 37.87mm obturator foramen (F). The pooled average dimensions of the bony landmarks in South African males were calculated. The average width of the ischial tuberosity was 32.91mm, 55.52mm for the height of the obturator area, and 18.89mm for the width of the ischiopubic ramus.

**Table 2.** Representation of measurements made between landmarks

Measurements	Landmark measurement points
A – C	Distance from obturator canal to mesh
A – E	Distance from obturator canal to inferior most point on pubic symphysis
A – B	Distance from obturator canal to most inferior point of adductor longus tendon
B – C	Distance from most inferior point of adductor longus tendon to mesh
C – D	Distance from mesh to most medial point of the obturator foramen
C – E	Distance from mesh to most inferior point of the pubic symphysis
C – F	Distance from mesh to most inferior point of the obturator foramen
F – A	Distance from most inferior point of the obturator foramen to obturator canal
G – F	Distance from most inferior point of the ischial tuberosity to most inferior point of the obturator foramen
H – A	Distance from posterior branch of obturator nerve, from a horizontal line to where the mesh exits, to the obturator canal
H – C	Distance from the shortest distance from the posterior branch of obturator nerve to the mesh
H – F	Distance from posterior branch of obturator nerve to most inferior point of the obturator foramen
D – I	Distance from the most medial point of the obturator foramen to the junction of the ischiopubic ramus and the body of the pubis

Basic descriptive statistics for the female cadavers (n=7) who received the TOT outside-in and TVT-O inside-out procedure are presented in table 4. On average the posterior branch of the obturator nerve (H) was found to be 22.80mm from the obturator canal (A) and 34.38mm from the obturator foramen (F).

A safe area for the TOT outside-in mesh (C) in females (n=7) was determined. Results showed, that the mesh should be located on average, 27.02mm from the obturator canal (A), 38.32mm from the tendon of adductor longus (B), 9.38mm from the medial point of obturator foramen (D), 24.74mm from the most inferior point of the pubic symphysis (E) and 32.00mm from the most inferior point of the obturator foramen (F).

The average distances for the location of the TVT-O inside-out mesh (C) were found to be 20.79mm from the obturator canal (A), 45.05mm from the tendon of adductor longus (B), 6.97 and 17.49mm from the medial point of obturator foramen (D), 35.07mm from the most inferior point of the pubic symphysis (E), 28.17mm from the obturator foramen (F).

The pooled average for the measurements taken between the bony landmarks of South African females showed that the average width of the ischial tuberosity was 30.88mm and the width of the ischiopubic ramus was 16.38mm. The average height of the obturator area was 50.43mm.

There was a statistically significant difference (P-value $\leq$ 0.05) found in the position of the mesh between the TOT outside-in and TVT-O inside-out methods in females. The differences were concerning the relation of the mesh (C) to obturator foramen (D), the common inferior point of the pubic symphysis (E), and the posterior branch of the obturator nerve (H). These differences showed that there is variation in the trajectory of the needles in the different procedures in association to the obturator nerve

and surrounding landmarks in females.

### Discussion

This study serves to assist in the quantification of a safe area for the placement of transobturator slings in a South African males and females. The PBON was mostly at risk during these perineal procedures in both males and females. The trajectory of the needles was found to be consistent with studies performed by other researchers, piercing the gracilise, adductor brevis and adductor magnus muscles (16, 19).

Analysis of the data points revealed that the relation between the mesh and most medial point of the obturator foramen, in both males and females, was an important landmark in the determination of a safe area for these procedures. It was found that when the needle passed inferior to the most medial point of the obturator foramen, closer to the lateral border of the ischiopubic ramus, the mesh would be further from the PBON. A correlation was found between the distance from the mesh to the most medial point of the obturator foramen (C-D) and the shortest distance from the posterior branch of obturator nerve to the mesh (H-C). The shorter the distance between the most medial point of the obturator foramen and the mesh, C-D, the further the mesh would pass from the obturator nerve, H-C. In cases where the needles passed superior to the most medial point of the obturator foramen, the mesh either went through the obturator canal or came relatively close to the posterior branch and should be noted by surgeons when performing these procedures.

Studies by other researchers used the midpoint of the ischiopubic ramus as a reference point to measure relations of the mesh. To determine the midpoint, the length of the ischiopubic ramus was measured from the most inferior point of the pubic symphysis to the most inferior point of the ischiopubic ramus (16). This study suggests that

**Table 3.** Mean values for the male TOT inside-out technique. Values given in mm.

	Sample size	A - C	A - E	A - B	B - C	C - D	C - E	C - F	F - A	G - F	H - A	H - C	H - F	D - I
<b>Black Males</b>	7	25.77	46.92	41.82	36.40	12.24	25.49	39.62	52.19	30.21	26.69	12.74	38.03	15.27
<b>White Males</b>	7	24.30	53.83	45.69	36.81	15.48	34.47	36.12	58.85	35.61	19.93	17.90	43.18	22.51
<b>Pooled Males</b>	14	25.03	50.38	43.75	36.61	13.86	29.98	37.87	55.52	32.91	23.31	15.32	40.61	18.89
<b>P-value</b>	7 black vs. 7 white	0.72	0.01	0.21	0.87	0.48	0.11	0.49	0.33	0.01	0.13	0.32	0.02	0.01

**Table 4.** Mean values for the female TOT outside-in and TVT-O inside-out techniques, given in mm

	Sample Size	A - C	A - E	A - B	B - C	C - D	C - E	C - F	F - A	G - F	H - A	H - C	H - F	D - I
<b>TOT</b>	7	27.02	48.42	45.82	38.32	9.38	24.74	32.00	50.80	29.53	22.36	21.49	34.18	17.23
<b>TVT-O</b>	7	20.79	48.47	47.47	45.05	17.49	35.07	28.17	50.05	32.22	23.24	13.73	34.58	15.52
<b>Pooled Females</b>	14	23.90	48.44	46.64	41.69	13.44	29.90	30.09	50.43	30.88	22.80	17.61	34.38	16.38
<b>P-value</b>	TOT vs. TVT-O		0.96	0.30					0.63	0.16	0.82		0.90	0.23

the most medial point of the obturator foramen is a more reliable landmark to use, as it is palpable through the dissected plane.

This study is the first anatomical paper of its kind to attempt to quantify a safe area for the needle trajectory in the male TOT inside-out procedure in South Africa. The male transobturator slings are relatively new products, with the main current research focus being the technique and clinical implications of the procedure itself in terms of curing or treating stress urinary incontinence (10). Safe areas by Bauer et al., (2005) were not quantified; the researchers qualitatively described the area using the approximate vicinity of the obturator nerve as a determinant (23).

The results for the female procedures are comparable with those found by other researchers. The mean distance between the mesh and nerve among our female sample was 21.49mm and 13.73mm for TOT outside-in and out, respectively. These results suggest that the TVT-O inside-out mesh travels closer to the posterior branch of the obturator nerve than the TOT outside-in procedure. Whiteside and Walters (16), (24) Whiteside and Walters (16), performed a study on six fresh female cadavers and found a mean distance of 25mm between the mesh and the posterior branch of the obturator nerve in the TOT outside-in procedure (16). Spinosa, Dubuis (21) Spinosa, and Dubuis (21) performed a similar study where they placed the TOT outside-in tape in five fresh cadavers in Switzerland. They reported a distance of 27mm between the posterior branch of the obturator nerve and the TOT mesh. Ahtari, Mckenzie (18). Other researchers also

found a mean distance of 27mm in the TVT-O inside-out procedure (18, 21). These comparisons revealed that both tape procedures might be more dangerous to perform on a South-African population group.

Variability in pelvic osteology may have further implications for the outcome of these transobturator procedures. Apart from the high degree of sexual dimorphism of the pelvis (25), a great deal of variation exists among populations concerning robusticity, degree of sexual dimorphism, and body size (25, 26). The differences in pelvic dimensions between sexes and population groups are more significant in the inferior aperture than at the pelvic brim (27).

Variations in the size and shape of the obturator foramen (28), the width of the ischiopubic ramus (29), and subpubic angle between sexes and population groups have been reported (28, 30). Significant variation in height and form of the obturator foramen and subpubic angle in African American and European American females has been found (31). Apart from population affinity, it was found that stature was a contributing factor. The authors suggested that the high variability of the obturator foramen in females and the correlation of the obturator foramen and subpubic angle with stature may have implications for urogenital surgical procedures involving the transobturator approach (28). Further studies have found a correlation between the height and shape of the obturator foramen, ischiopubic ramus width, and the trajectory of the needles during transobturator procedures (17). However, these studies included various population groups, and (30) the anatomical variations noted in South

Africans have not been investigated.

This anatomical paper was undertaken to clarify the relationship of the obturator nerve, in a South African sample, to the TOT inside-out procedure in males and the TOT outside-in and TVT-O inside-out procedures in females. The study also strives to determine a safe area to avoid damage to the nerve and its branches during placement of the mesh, using surgical needles during these procedures.

In conclusion, the average distance between the mesh and the posterior branch of the obturator nerve in females was 15mm. This is a significantly small distance, half the length of what has been described as a safe distance (16, 21). This should be considered when the procedure is performed on males. The study showed that the TOT outside-in procedure in South African females poses less risk to the obturator nerve and its branches than the TVT-O inside-out procedure. The study quantifies a safe area for the passage of the needles in both South African males and females concerning the most medial point of the obturator foramen. The area is described as inferior to the obturator foramen, closer to the lateral border of the ischiopubic ramus within the obturator foramen. The results concerning the safety of the procedures between TVT-O inside-out and TOT outside-in may correspond with other studies, but the mesh in a South African population is closer to the posterior branch of the obturator nerve compared to the populations researched. The needles are developed based on European populations' pelvic dimensions, using American results as the golden standard. Bauer, Karik (23) and Bauer et al., (29) developed the male TOT in Austria, Delorme (7) developed the female TOT outside-in procedure in France and de Leval (11) modified the TVT procedure to the TVT-O inside-out procedure in Belgium (7, 11, 23). It is necessary to note that anatomical variations play a role in the outcome and success of these SUI procedures in South Africa. It is suggested that research is performed to standardize needles for a South African population and confirm it in a clinical setting.

### Conclusions

The findings may be attributed to the South African population's differences in body size and pelvic osteology. This study's suggested safe route for the passage of the needles is inferior to the obturator foramen, closer to the lateral border of the ischiopubic ramus. It is recommended that needles be standardized for the population of South Africa.

### Authors' contributions

RHB: Protocol development, manuscript writing and proofreading, ZN.T: Protocol development, data collection and data analyses, manuscript proofreading, SVDW:

Protocol development; data collection, manuscript proofreading

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### Conflict of interest

All authors declare that there is no potential competing or conflict of interest.

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### Ethics statement

The Department of Anatomy, University of Pretoria are the custodians of the Human cadaver specimens. The study falls under the auspices of the Nation Health Act 2003. Ethical clearance for the study was obtained from the Ethics Committee of the Faculty of University of Pretoria (74-2013).

### Data availability

Data will be provided on request.

### Abbreviations

PBON	Posterior branch of the obturator nerve
SUI	Stress urinary incontinence
TOT	Transobturator tape
TVT	Tension-free vaginal tape
TVT-O	Tension-free vaginal tape – obturator

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