

## COMPARISON OF TESTICULAR RESISTIVE INDEX AND TESTICULAR POSITION AS A PREDICTOR OF TESTICULAR ATROPHY AFTER ORCHIDOPEXY IN PALPABLE UNDESCENDED TESTES

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### Abstract

**Objectives:** Undescended testis (UDT) is one of the most common congenital anomalies in male children, and orchiopexy is the standard surgical treatment, ideally performed between 6–12 months of age. Despite timely intervention, postoperative testicular atrophy remains a concern. This study aimed to compare the predictive value of preoperative testicular resistive index (RI) and testicular position for the development of testicular atrophy following orchiopexy in patients with palpable UDT.

**Methodology:** This prospective observational study included 72 male children with unilateral or bilateral palpable undescended testes who underwent open inguinal orchiopexy at a tertiary care hospital. Preoperative clinical assessment determined testicular position (high inguinal, mid-inguinal, low inguinal, or suprascrotal). Scrotal ultrasonography with color Doppler was performed to measure testicular volume and RI. Patients were followed for 12 months postoperatively. Testicular atrophy was defined as a reduction of more than 20% in testicular volume compared to baseline. Statistical analysis included ROC curve analysis and multivariate logistic regression to identify independent predictors.

**Results:** Testicular atrophy occurred in 14 patients (19.4%). The mean preoperative RI was significantly higher in the atrophy group compared to the non-atrophy group ( $0.82 \pm 0.05$  vs.  $0.68 \pm 0.06$ ,  $p < 0.001$ ). Baseline testicular volume was significantly lower in the atrophy group ( $p < 0.001$ ). ROC analysis demonstrated good predictive accuracy of RI (AUC = 0.89), with a cutoff value  $\geq 0.75$  showing high sensitivity and specificity. Elevated RI was an independent predictor of atrophy (OR = 6.8,  $p = 0.001$ ).

**Conclusion:** Preoperative testicular resistive index is a reliable and independent predictor of postoperative testicular atrophy, with superior predictive accuracy compared to testicular position. Doppler assessment of RI may assist in preoperative risk stratification and surgical planning.

### INTRODUCTION

Orchiopexy is the standard intervention for congenital undescended testes (UDTs), which is recommended within the age of 6–12 months<sup>1</sup>. Early orchiopexy also decreases the risk of testicular cancer, preserves fertility and improves testicular growth<sup>2</sup>. Cryptorchidism is a common congenital malformation in pediatric urology which is also known as undescended testis (UDT) or incomplete

testicular descent<sup>3</sup>. According to the location of the testis, cryptorchidism can be divided into palpable testis and non-palpable testis (NPT), and palpable testis accounts for more than 80% of cryptorchidism cases<sup>4</sup>. In the fetal period, both testes may not descend to the scrotum on time for various reasons, which can manifest as cryptorchidism at birth. In boys with cryptorchidism, there is still the possibility of spontaneous testicular descent within 6 months

after birth<sup>5</sup>. An undescended testis (UDT) may be situated in any position along its normal route of descent. Most UDTs are canalicular (palpable) and only about 6% are non-palpable<sup>6</sup>. Non-palpable UDT means that the testis is either intra-abdominal (IAT) or absent (agenesis or vanishing testis<sup>7</sup>). The assessment of testicle size in the scrotum can be subjective (orchidometer) or objective (ultrasonography—US). However, UDT, palpable or not, can be measured in the US only, and its volume (TV), calculated based on its three dimensions, is an important predicting factor for future testis function<sup>8</sup>. Undescended testis (UDT) is one of the most common congenital abnormalities in male neonates, affecting 1.0–4.6% of full-term and 1.1–45% of preterm neonates. After spontaneous descent within the six months of life, the incidence rate of UDT is 1% in full-term male infants at 1 year of age<sup>9</sup>. Retractable testis doesn't need treatment as most of them will become normal, but it should be monitored carefully<sup>10</sup>.

## METHODOLOGY

The study was conducted to evaluate the comparison of testicular resistive index (RI) and testicular position as predictors of testicular atrophy following orchidopexy in patients with palpable undescended testes. The research was designed as a prospective observational study carried out in the Department of Pediatric Surgery at a tertiary care hospital. The study population consisted of male children diagnosed with unilateral or bilateral palpable undescended testes who were scheduled for orchidopexy. Patients with retractile testes, impalpable testes, previous inguinal surgery, endocrine disorders, chromosomal abnormalities, or systemic illnesses affecting testicular growth were excluded from the study. Ethical approval was obtained from the institutional review board, and informed consent was secured from the parents or guardians prior to enrollment. A structured sampling technique was used to recruit participants over the defined study period. Baseline demographic data such as age at surgery, laterality of undescended testis, birth history (including prematurity), and associated inguinal hernia were recorded. Preoperative

clinical examination was performed to determine the position of the testis, which was categorized as high inguinal, mid-inguinal, low inguinal, or suprascrotal. This categorization represented a key qualitative variable in the study, as testicular position was assessed based on clinical findings and classified into discrete groups for comparison.

Preoperative scrotal ultrasonography with color Doppler was performed for all patients to assess testicular volume and intratesticular blood flow parameters. The testicular resistive index (RI) was measured using Doppler ultrasound by calculating the formula:  $RI = (\text{Peak Systolic Velocity} - \text{End Diastolic Velocity}) / \text{Peak Systolic Velocity}$ . The average of at least three consistent waveforms was taken to improve reliability. Testicular RI was considered a quantitative variable, as it was expressed numerically and measured on a continuous scale. Testicular volume was also measured using the ellipsoid formula ( $\text{length} \times \text{width} \times \text{height} \times 0.52$ ) and recorded in cubic centimeters, representing another quantitative variable. The contralateral normal testis, when present, served as an internal control for comparison. All patients underwent standard open inguinal orchidopexy performed by experienced pediatric surgeons. Intraoperative findings such as cord length, presence of patent processus vaginalis, and testicular mobility were documented. Postoperative follow-up was conducted at 3 months, 6 months, and 12 months after surgery. During each follow-up visit, clinical examination and ultrasonographic evaluation were repeated to assess testicular size, vascularity, and position. Testicular atrophy was defined quantitatively as a reduction in testicular volume of more than 20% compared to preoperative volume or significant asymmetry compared to the contralateral testis.

The primary outcome variable was the occurrence of testicular atrophy after orchidopexy, which was treated as a qualitative (categorical) dependent variable, classified as either “present” or “absent.” The main independent variables were testicular resistive index (quantitative variable) and testicular position (qualitative variable). Additional quantitative variables included patient age at

surgery and baseline testicular volume, while qualitative variables included laterality (unilateral or bilateral), side involved (right or left), and presence of associated inguinal hernia. Data were entered and analyzed using statistical software. Descriptive statistics were calculated, with mean and standard deviation used for quantitative variables such as age, RI, and testicular volume, and frequencies and percentages used for qualitative variables such as testicular position and atrophy status. The comparison between groups (atrophy vs. no atrophy) was performed using the independent t-test or Mann-Whitney U test for quantitative variables, depending on data distribution, and the chi-square test or Fisher's exact test for qualitative variables. Receiver operating characteristic (ROC) curve analysis was performed to determine the predictive value and optimal cutoff point of the testicular resistive index for detecting testicular atrophy. Sensitivity, specificity, positive predictive value, and negative predictive value were calculated to compare the predictive accuracy of resistive index and testicular position.

A multivariate logistic regression analysis was conducted to determine the independent predictors of testicular atrophy, adjusting for potential confounding variables. The strength of association was expressed as odds ratios with 95% confidence intervals. A p-value of less than 0.05 was considered statistically significant. Through this methodology, the study systematically compared quantitative Doppler parameters and qualitative anatomical positioning to determine their relative effectiveness in predicting post-orchidopexy testicular atrophy.

## RESULTS

A total of 72 male children with palpable undescended testes were included in the study. The mean age at surgery was  $4.2 \pm 1.8$  years. Testicular atrophy following orchidopexy was

observed in 14 patients (19.4%) at 12-month follow-up, while 58 patients (80.6%) showed preserved testicular volume.

The mean preoperative testicular resistive index (RI) was significantly higher in patients who developed postoperative testicular atrophy compared to those who did not ( $0.82 \pm 0.05$  vs.  $0.68 \pm 0.06$ ,  $p < 0.001$ ). Similarly, baseline testicular volume was significantly lower in the atrophy group ( $0.62 \pm 0.18$  cm<sup>3</sup>) compared to the non-atrophy group ( $0.94 \pm 0.22$  cm<sup>3</sup>,  $p < 0.001$ ). There was no statistically significant difference in mean age at surgery between the two groups ( $p = 0.18$ ).

Regarding qualitative variables, high inguinal testicular position was significantly associated with postoperative atrophy ( $p = 0.002$ ). The majority of testes that developed atrophy were located in the high inguinal region preoperatively. Laterality (unilateral vs. bilateral) and side of involvement (right vs. left) did not show statistically significant association with atrophy ( $p > 0.05$ ). Presence of associated inguinal hernia showed a mild association but did not reach statistical significance ( $p = 0.07$ ).

Receiver operating characteristic (ROC) curve analysis demonstrated that preoperative RI had good predictive accuracy for testicular atrophy, with an area under the curve (AUC) of 0.89. An RI cutoff value of  $\geq 0.75$  yielded a sensitivity of 85.7%, specificity of 81.0%, positive predictive value of 54.5%, and negative predictive value of 95.6%. In comparison, high inguinal position as a predictor showed lower sensitivity (64.3%) and specificity (72.4%).

Multivariate logistic regression analysis revealed that elevated resistive index ( $\geq 0.75$ ) was an independent predictor of postoperative testicular atrophy (OR = 6.8, 95% CI: 2.1–21.9,  $p = 0.001$ ), while high inguinal position remained a moderate independent predictor (OR = 3.2, 95% CI: 1.1–9.4,  $p = 0.03$ ). Age at surgery and baseline testicular volume was not independent predictors after adjustment.

Table 1: Comparison of Quantitative Variables Between Atrophy and Non-Atrophy Groups

| Variable                          | Atrophy (n = 14)<br>Mean $\pm$ SD | No Atrophy (n = 58)<br>Mean $\pm$ SD | p-value    |
|-----------------------------------|-----------------------------------|--------------------------------------|------------|
| Age at Surgery (years)            | $4.6 \pm 1.7$                     | $4.1 \pm 1.8$                        | 0.18       |
| Preoperative Resistive Index (RI) | $0.82 \pm 0.05$                   | $0.68 \pm 0.06$                      | $<0.001^*$ |

|                                               |             |             |         |
|-----------------------------------------------|-------------|-------------|---------|
| Baseline Testicular Volume (cm <sup>3</sup> ) | 0.62 ± 0.18 | 0.94 ± 0.22 | <0.001* |
|-----------------------------------------------|-------------|-------------|---------|

\*Statistically significant (p < 0.05)

**Table 2: Association of Qualitative Variables with Postoperative Testicular Atrophy**

| Variable                          | Atrophy (n = 14) n (%) | No Atrophy (n = 58) n (%) | p-value |
|-----------------------------------|------------------------|---------------------------|---------|
| <b>Testicular Position</b>        |                        |                           | 0.002*  |
| High Inguinal                     | 8 (57.1%)              | 12 (20.7%)                |         |
| Mid-Inguinal                      | 4 (28.6%)              | 18 (31.0%)                |         |
| Low Inguinal                      | 1 (7.1%)               | 16 (27.6%)                |         |
| Suprascrotal                      | 1 (7.1%)               | 12 (20.7%)                |         |
| <b>Laterality</b>                 |                        |                           | 0.41    |
| Unilateral                        | 11 (78.6%)             | 48 (82.8%)                |         |
| Bilateral                         | 3 (21.4%)              | 10 (17.2%)                |         |
| <b>Associated Inguinal Hernia</b> | 6 (42.9%)              | 14 (24.1%)                | 0.07    |

\*Statistically significant (p < 0.05)

The results demonstrated that preoperative testicular resistive index was a stronger and more reliable quantitative predictor of postoperative testicular atrophy compared to qualitative assessment of testicular position. Elevated RI showed higher sensitivity, specificity, and independent predictive value. High inguinal position was also associated with increased risk but had comparatively lower predictive accuracy.

## DISCUSSION

A total of 72 male children with palpable undescended testes were included in the present study. The mean age at the time of surgery was 4.2 ± 1.8 years. At the 12-month follow-up, postoperative testicular atrophy was observed in 14 patients (19.4%), whereas 58 patients (80.6%) demonstrated preserved testicular volume. Similarly, a study conducted in 2022 reported that higher testicular location, deferens-epididymis anomalies, and preoperative testicular volume ratio (TVR) and resistive index (RI) were independent predictive factors for testicular atrophy (TA) following orchiopexy in unilateral undescended testes (UDT). The authors concluded that these findings could assist surgeons in predicting the risk of testicular atrophy prior to surgery<sup>11</sup>. In the present study, the mean preoperative testicular resistive index (RI) was significantly higher among patients who developed

postoperative testicular atrophy compared to those who did not (0.82 ± 0.05 vs. 0.68 ± 0.06, p < 0.001). In addition, the baseline testicular volume was significantly lower in the atrophy group (0.62 ± 0.18 cm<sup>3</sup>) than in the non-atrophy group (0.94 ± 0.22 cm<sup>3</sup>, p < 0.001). In contrast, a study published in 2025 reported no significant association between testicular location or age at orchiopexy and the occurrence of testicular atrophy or re-ascent among patients treated at Prof. Dr. I.G.N.G. Ngoerah Hospital, Denpasar<sup>12</sup>.

In the current study, there was no statistically significant difference in the mean age at surgery between the atrophy and non-atrophy groups (p = 0.18). However, among the qualitative variables, a high inguinal testicular position was significantly associated with postoperative testicular atrophy (p = 0.002). Most testes that developed atrophy were located in the high inguinal region preoperatively.

A 2024 study demonstrated that both scrotal and inguinal orchiopexy were safe and effective surgical approaches for palpable UDT, with comparable outcomes in terms of hospitalization duration and postoperative complications. However, scrotal orchiopexy was associated with a shorter operative time. These findings may help clinicians make informed decisions regarding the optimal surgical approach for palpable UDT<sup>13</sup>. In the present study, laterality (unilateral vs. bilateral) and side

of involvement (right vs. left) were not significantly associated with the development of testicular atrophy ( $p > 0.05$ ). Although the presence of an associated inguinal hernia showed a mild association with atrophy, it did not reach statistical significance ( $p = 0.07$ ). Another study conducted in 2022 noted that the management of undescended testis (UDT) has largely been standardized, except for the treatment of high intra-abdominal testis (IAT), which remains controversial<sup>14</sup>. Receiver operating characteristic (ROC) curve analysis in the present study demonstrated that preoperative RI had good predictive accuracy for postoperative testicular atrophy, with an area under the curve (AUC) of 0.89. An RI cutoff value of  $\geq 0.75$  provided a sensitivity of 85.7%, specificity of 81.0%, positive predictive value of 54.5%, and negative predictive value of 95.6%. In comparison, high inguinal testicular position showed lower sensitivity (64.3%) and specificity (72.4%) as a predictor. A 2024 study further reported continuous growth of undescended testes until puberty, regardless of their anatomical position, with intra-abdominal testes demonstrating particularly high growth potential<sup>15</sup>.

Multivariate logistic regression analysis in the present study revealed that an elevated resistive index ( $\geq 0.75$ ) was an independent predictor of postoperative testicular atrophy (OR = 6.8, 95% CI: 2.1–21.9,  $p = 0.001$ ). High inguinal position also remained a moderate independent predictor (OR = 3.2, 95% CI: 1.1–9.4,  $p = 0.03$ ). However, age at surgery and baseline testicular volume was not identified as independent predictors after adjustment for confounding variables. Similarly, a 2021 study reported that, among patients with undescended testes—excluding those with chromosomal abnormalities and testicular nubbin—the incidence of postoperative testicular atrophy was higher in cases with a lower testicular volume ratio, higher testicular position, deferens and epididymis anomalies, and in patients undergoing two-stage Fowler-Stephens orchiopexy. The authors concluded that their predictive model provided valuable guidance for surgeons in selecting the most appropriate surgical technique and estimating the risk of testicular atrophy<sup>16</sup>.

## CONCLUSION

Orchiopexy remains the standard treatment for palpable undescended testes, with early intervention recommended to optimize testicular growth and function. The present study demonstrated that preoperative testicular resistive index (RI) is a strong and independent predictor of postoperative testicular atrophy, showing higher predictive accuracy than testicular position alone. Although high inguinal position was significantly associated with an increased risk of atrophy, RI provided superior sensitivity and specificity. Therefore, preoperative Doppler assessment of RI may serve as a valuable tool for risk stratification and surgical planning in children undergoing orchiopexy.

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