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Early Testicular Volume Ratio Predicts Growth Failure after Redo Orchiopexy in Children

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Abstract

Purpose

Redo orchiopexy is usually assessed by postoperative scrotal position, but this may not reflect long-term testicular growth. This study evaluated whether early postoperative testicular volume ratio (TVR) predicts long-term growth failure after unilateral redo orchiopexy in children.

Materials and Methods

A retrospective cohort study was performed including children who underwent unilateral redo orchiopexy between January 2013 and January 2023. Early postoperative ultrasonography was performed 6–12 months after surgery, and long-term evaluation was performed at > = 24 months. TVR was calculated as operated testicular volume divided by contralateral testicular volume x100. Long-term growth failure was defined as long-term TVR < 50% and/or failure to demonstrate interval catch-up growth between early and long-term follow-up. The discriminative ability of early TVR was evaluated using receiver operating characteristic analysis.

Results

Sixty-eight children met the inclusion criteria. Mean age at redo orchiopexy was 7.8 +/- 2.9 years, and median follow-up was 36 months. Long-term growth failure occurred in 20 patients (29.4%). Children with growth failure had significantly lower early TVR than those with preserved growth (48.6 +/- 13.2% vs. 80.4 +/- 16.8%, p < 0.001). Early TVR showed good discrimination for predicting growth failure, with an area under the curve of 0.84 (95% CI, 0.72–0.96). A 55% cutoff yielded 82% sensitivity, 78% specificity, 69% positive predictive value, and 88% negative predictive value. Early TVR < 55%, reduced Doppler perfusion, and high inguinal/non-palpable initial testis position were independent predictors of growth failure.

Conclusion

Early postoperative TVR may help identify children at risk for long-term growth failure after unilateral redo orchiopexy. The proposed 55% threshold should be considered exploratory and requires external validation.

Introduction

Cryptorchidism is one of the most common congenital anomalies in boys and may adversely affect testicular development if not corrected in a timely manner. Current pediatric urology guidelines recommend timely orchiopexy to optimize testicular outcomes and reduce long-term risks [1].

Ultrasonographic studies have shown that earlier correction is associated with better testicular morphology and catch-up growth [2, 3]. Testicular volume before and after orchiopexy has therefore become an important objective marker of postoperative testicular development [4].

Although primary orchiopexy is successful in most children, a subset requires redo orchiopexy because of recurrent ascent, inadequate scrotal positioning, or unsatisfactory postoperative location. Redo orchiopexy is technically more challenging than primary orchiopexy because scar tissue, reduced spermatic cord mobility, and vascular compromise may affect the final outcome [5–7]. Previous redo orchiopexy series have reported variable rates of volume recovery, recurrent ascent, and postoperative atrophy [8, 9].

Most reports on redo orchiopexy focus on final scrotal position. However, a testis may remain in the scrotum while still showing poor growth. Postoperative testicular volume and asymmetry may remain abnormal even after technically successful orchiopexy [10–12].

Ultrasonographic testicular volume is a practical marker of testicular growth. In unilateral disease, comparison with the contralateral descended testis provides an internal reference that partially adjusts for age, body size, and pubertal development [2–4, 10–12]. For this reason, TVR was selected as the main volumetric parameter in the present study. Nevertheless, TVR is not a direct measure of fertility, endocrine function, or histologic viability. It may also be affected by compensatory hypertrophy of the contralateral testis.

Yang et al. developed a prediction model for testicular atrophy after orchiopexy and identified testicular volume ratio, testicular location, deferens/epididymal anomalies, and surgical technique as relevant predictors [13]. However, evidence regarding the predictive value of early postoperative TVR specifically after unilateral redo orchiopexy remains limited.

This study aimed to evaluate whether early postoperative TVR predicts long-term testicular growth failure after unilateral redo orchiopexy in children.

Materials and Methods

Study Design

This retrospective cohort study reviewed children who underwent unilateral redo orchiopexy at a tertiary pediatric urology center between January 2013 and January 2023.

The study was approved by the Institutional Ethics Committee (Approval No. 109674; Date: 13 February 2024). The study was conducted in accordance with the Declaration of Helsinki. Owing to the retrospective design and anonymized data collection, the requirement for written informed consent was waived.

Patient Selection

Children were included if they met all of the following criteria: unilateral redo orchiopexy, previous ipsilateral orchiopexy, normal contralateral descended testis, early postoperative ultrasonography at 6–12 months, and long-term ultrasonographic follow-up at > = 24 months.

Children were excluded if they had bilateral cryptorchidism, bilateral redo orchiopexy, monorchidism, previous testicular torsion, endocrine disorder, abnormal contralateral testis, or incomplete ultrasonographic data.

Ultrasonographic Assessment

Testicular dimensions were measured using scrotal ultrasonography. Testicular volume was calculated according to the Lambert formula:

Volume = length x width x height x 0.71

TVR was calculated as:

TVR (%) = operated testis volume / contralateral testis volume x100

Early TVR was defined as TVR measured 6–12 months after redo orchiopexy. Long-term TVR was defined as TVR measured at > = 24 months.

Doppler perfusion was classified as normal or reduced according to the radiology report. Because of the retrospective design, Doppler assessment was not based on a uniform quantitative vascular protocol.

Outcome Definition

The primary outcome was long-term testicular growth failure. Growth failure was defined as long-term TVR < 50% and/or failure to demonstrate interval catch-up growth between early postoperative and long-term follow-up assessments.

Failure to demonstrate interval catch-up growth was defined as no measurable increase in operated testicular volume between early postoperative and long-term ultrasonographic assessments.

Early TVR was evaluated as a prognostic marker measured at 6–12 months, whereas the outcome was assessed at > = 24 months. The early TVR cutoff of 55% was derived from ROC analysis and should be considered exploratory.

Statistical Analysis

Continuous variables were analyzed using Student's t-test or Mann-Whitney U test according to data distribution. Categorical variables were compared using the Chi-square test or Fisher's exact test.

The discriminative ability of early TVR was assessed using receiver operating characteristic analysis. The area under the curve was reported with an approximate 95% confidence interval. The optimal cutoff was determined using the Youden index.

To reduce model overfitting, multivariable logistic regression was restricted to three clinically relevant predictors chosen a priori: early TVR < 55%, reduced Doppler perfusion, and high inguinal/non-palpable initial testis position. Age at redo orchiopexy, interval between surgeries, and initial absolute testicular volume were not included in the final model because of the limited number of outcome events.

Results were reported as odds ratios with 95% confidence intervals. A p value < 0.05 was considered statistically significant.

Results

Baseline Characteristics

A total of 68 children met the inclusion criteria. Mean age at primary orchiopexy was 2.4 +/- 1.6 years. Mean age at redo orchiopexy was 7.8 +/- 2.9 years. Median follow-up duration was 36 months.

The affected side was right in 40 patients (58.8%) and left in 28 patients (41.2%). Mean interval between primary and redo orchiopexy was 4.5 +/- 2.3 years.

Initial testis location was inguinal in 43 patients (63.2%), high inguinal in 17 patients (25.0%), and non-palpable in 8 patients (11.8%). Associated inguinal hernia was present in 22 children (32.4%).

Testicular Volume Outcomes

Mean early operated testis volume was 1.18 +/- 0.54 mL, whereas mean contralateral testis volume was 1.63 +/- 0.61 mL. Mean early TVR was 71.2 +/- 24.5%.

At long-term follow-up, 48 children (70.6%) demonstrated preserved growth, whereas 20 children (29.4%) developed long-term growth failure.

Comparison between Groups

Children with growth failure had significantly lower early TVR values than those with preserved growth: 48.6 +/- 13.2% versus 80.4 +/- 16.8% (p < 0.001).

The growth-failure group had older age at redo orchiopexy (8.9 +/- 3.1 vs. 7.3 +/- 2.7 years, p = 0.04) and a longer interval between surgeries that approached statistical significance (5.3 +/- 2.5 vs. 4.1 +/- 2.1

years, p = 0.06). Early operated testis volume was significantly lower in the growth-failure group (0.62 +/- 0.21 vs. 1.41 +/- 0.43 mL, p < 0.001).

Reduced Doppler perfusion was significantly more common among patients with growth failure: 45.0% versus 6.3% (p < 0.001). High inguinal or non-palpable initial position was also more common in the growth-failure group: 50.0% versus 18.8% (p = 0.01).

ROC Analysis

Early TVR demonstrated good discrimination for predicting long-term growth failure, with an AUC of 0.84 (95% CI, 0.72–0.96).

The optimal cutoff value was 55%. At this cutoff, sensitivity was 82%, specificity was 78%, positive predictive value was 69%, and negative predictive value was 88%.

Multivariable Logistic Regression

Three independent predictors of long-term growth failure were identified: early TVR < 55% (OR 4.60, 95% CI 1.50–14.10, p = 0.008), reduced Doppler perfusion (OR 5.10, 95% CI 1.60–16.20, p = 0.006), and high inguinal/non-palpable initial position (OR 2.80, 95% CI 1.10–7.20, p = 0.031).

Discussion

This study suggests that early postoperative TVR is associated with long-term testicular growth after unilateral redo orchiopexy. Children with lower early TVR values were more likely to develop growth failure during follow-up.

The main finding was that an early TVR threshold of approximately 55% showed good discrimination for predicting long-term growth failure. This may help clinicians identify children who require closer ultrasonographic follow-up after redo orchiopexy. However, this threshold should be considered exploratory because it was derived from the present cohort and has not been externally validated.

These findings are consistent with previous studies showing that testicular volume and asymmetry are important postoperative markers after orchiopexy [2–4, 10–12]. Yang et al. reported that testicular volume ratio was an independent predictor of postoperative atrophy in a large pediatric orchiopexy cohort [13]. Unlike that study, the present analysis focused specifically on unilateral redo orchiopexy, a smaller but clinically important subgroup.

Approximately one-third of patients experienced long-term growth failure despite redo orchiopexy. This highlights an important limitation of judging surgical success by scrotal position alone. A testis may remain in the scrotum but still show poor growth over time. Previous redo orchiopexy studies have also reported variable rates of postoperative atrophy, persistent asymmetry, and impaired volume recovery [5–9].

Reduced Doppler perfusion was independently associated with poor growth. Although this association is biologically plausible, Doppler findings should be interpreted cautiously because perfusion was assessed using routine radiology reports rather than standardized quantitative Doppler parameters. Redo orchiopexy is technically challenging because scar tissue may surround the spermatic vessels and vas deferens, increasing the risk of vascular compromise during mobilization [5–7].

Initial testicular position also influenced outcome. Children with high inguinal or non-palpable testes had a higher risk of growth failure. This is consistent with earlier studies showing poorer volume outcomes in higher-positioned testes [12, 13, 15].

TVR should not be interpreted as a direct measure of fertility or endocrine function. Testicular volume is an imaging-based surrogate marker of growth preservation. Long-term reproductive outcomes require hormonal evaluation, semen analysis, and prospective follow-up. Previous long-term studies suggest that testicular volume alone may not directly correlate with paternity or future fertility outcomes [14].

The contralateral testis provides a practical internal reference, but this approach is imperfect. Compensatory hypertrophy of the contralateral testis can exaggerate relative volume loss on the operated side. Therefore, TVR should be interpreted together with absolute operated testis volume, Doppler perfusion, serial growth pattern, and clinical examination.

Clinical Implications

Children with early TVR < 55%, reduced Doppler perfusion, or high inguinal/non-palpable initial testicular position may benefit from closer ultrasonographic surveillance after redo orchiopexy. A structured follow-up strategy using early postoperative TVR may support risk stratification, but the 55% threshold should not be considered definitive until validated in independent cohorts.

In resource-limited settings where advanced fertility assessment is not routinely available, ultrasonographic TVR may represent a simple, inexpensive, and widely accessible tool for postoperative risk stratification following redo orchiopexy.

Limitations

This study has several limitations. First, its retrospective design may introduce selection bias. Second, this was a single-center study with a modest sample size. Third, Doppler assessment was based on routine clinical reporting rather than standardized quantitative vascular measurements. Fourth, hormonal and fertility-related outcomes were not available. Fifth, the contralateral testis may not be an ideal reference because compensatory hypertrophy can occur in unilateral cryptorchidism. Sixth, the predictor and outcome variables were derived from related volumetric measurements obtained at different time points. Although this temporal separation supports a prognostic framework, biological overlap cannot be excluded. Seventh, the early TVR cutoff was derived from the present cohort and should be considered exploratory. Finally, the study period extended from 2013 to 2023, during which surgical techniques, ultrasonography equipment, and radiology reporting practices may have evolved.

Conclusions

Early postoperative TVR may help identify children at increased risk of long-term testicular growth failure after unilateral redo orchiopexy. A TVR threshold of approximately 55% may guide closer surveillance, but this cutoff should be considered exploratory and requires external validation. TVR should be interpreted as an imaging-based risk-stratification marker rather than a direct measure of testicular function.

Declarations

Ethics Approval and Consent to Participate

This retrospective study was approved by the Institutional Ethics Committee (Approval No. 109674; Date: 13 February 2024). The study was conducted in accordance with the Declaration of Helsinki. Owing to the retrospective design and anonymized data collection, the requirement for written informed consent was waived.

Consent for Publication

Not applicable.

Competing Interests

The authors declare that they have no competing interests.

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No external funding was received.

Author Contribution

Y.A.B. conceived and designed the study. Y.A.B. and S.T.Ç. collected the data. Y.A.B.,S.T.Ç. and K.T. performed the statistical analysis and interpreted the results. Y.A.B.,S.T.Ç. and K.T. prepared the figures and tables. Ş.S.K. and Ö.Ö.drafted the manuscript. All authors critically revised the manuscript, approved the final version, and agreed to be accountable for all aspects of the work.

Data Availability

Yes. The study used retrospectively collected clinical and ultrasonographic data from children who underwent unilateral redo orchiopexy between January 2013 and January 2023. De-identified data were

analyzed to evaluate the association between early postoperative testicular volume ratio and long-term testicular growth outcomes.

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Tables

Table 1
Baseline Characteristics of the Study Cohort

Variable	**Total Cohort (n = 68)**
Age at primary orchiopexy, years	2.4 +/- 1.6
Age at redo orchiopexy, years	7.8 +/- 2.9
Follow-up duration, months	36
Right-sided testis	40 (58.8%)
Left-sided testis	28 (41.2%)
Interval between surgeries, years	4.5 +/- 2.3
Initial inguinal testis	43 (63.2%)
Initial high inguinal testis	17 (25.0%)
Initial non-palpable testis	8 (11.8%)
Associated inguinal hernia	22 (32.4%)
Values are presented as mean +/- SD, median, or n (%).	

Table 2
Comparison according to Long-Term Testicular Growth Outcome

Variable	Preserved Growth (n = 48)	Growth Failure (n = 20)	p value
Age at redo orchiopexy, years	7.3 +/- 2.7	8.9 +/- 3.1	0.04
Follow-up duration, months	35	38	0.52
Interval between surgeries, years	4.1 +/- 2.1	5.3 +/- 2.5	0.06
Early operated testis volume, mL	1.41 +/- 0.43	0.62 +/- 0.21	< 0.001
Contralateral testis volume, mL	1.71 +/- 0.58	1.45 +/- 0.47	0.11
Early TVR, %	80.4 +/- 16.8	48.6 +/- 13.2	< 0.001
Reduced Doppler perfusion	3 (6.3%)	9 (45.0%)	< 0.001
High inguinal/non-palpable testis	9 (18.8%)	10 (50.0%)	0.01
Associated inguinal hernia	14 (29.2%)	8 (40.0%)	0.38
TVR = testicular volume ratio.			

Table 3
Multivariable Logistic Regression for Long-Term Growth Failure

Variable	Odds Ratio	95% CI	p value
Early TVR < 55%	4.60	1.50–14.10	0.008
Reduced Doppler perfusion	5.10	1.60–16.20	0.006
High inguinal/non-palpable initial position	2.80	1.10–7.20	0.031

Figures

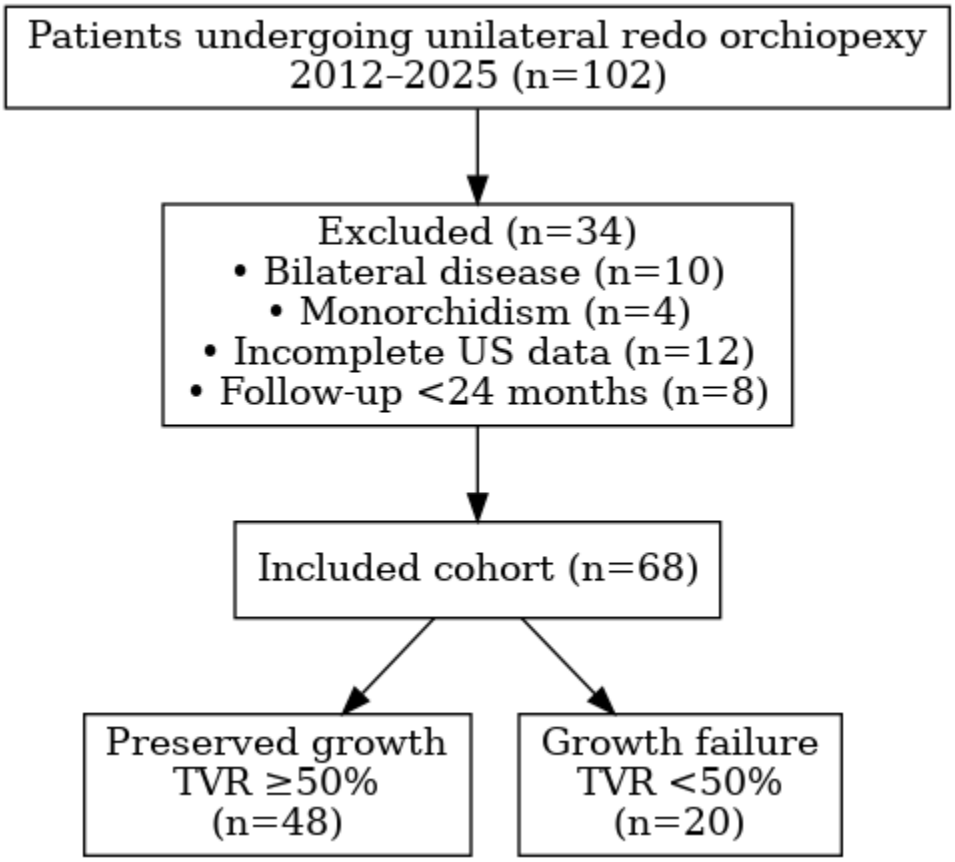


Figure 1

Flow diagram of patient selection and study inclusion.

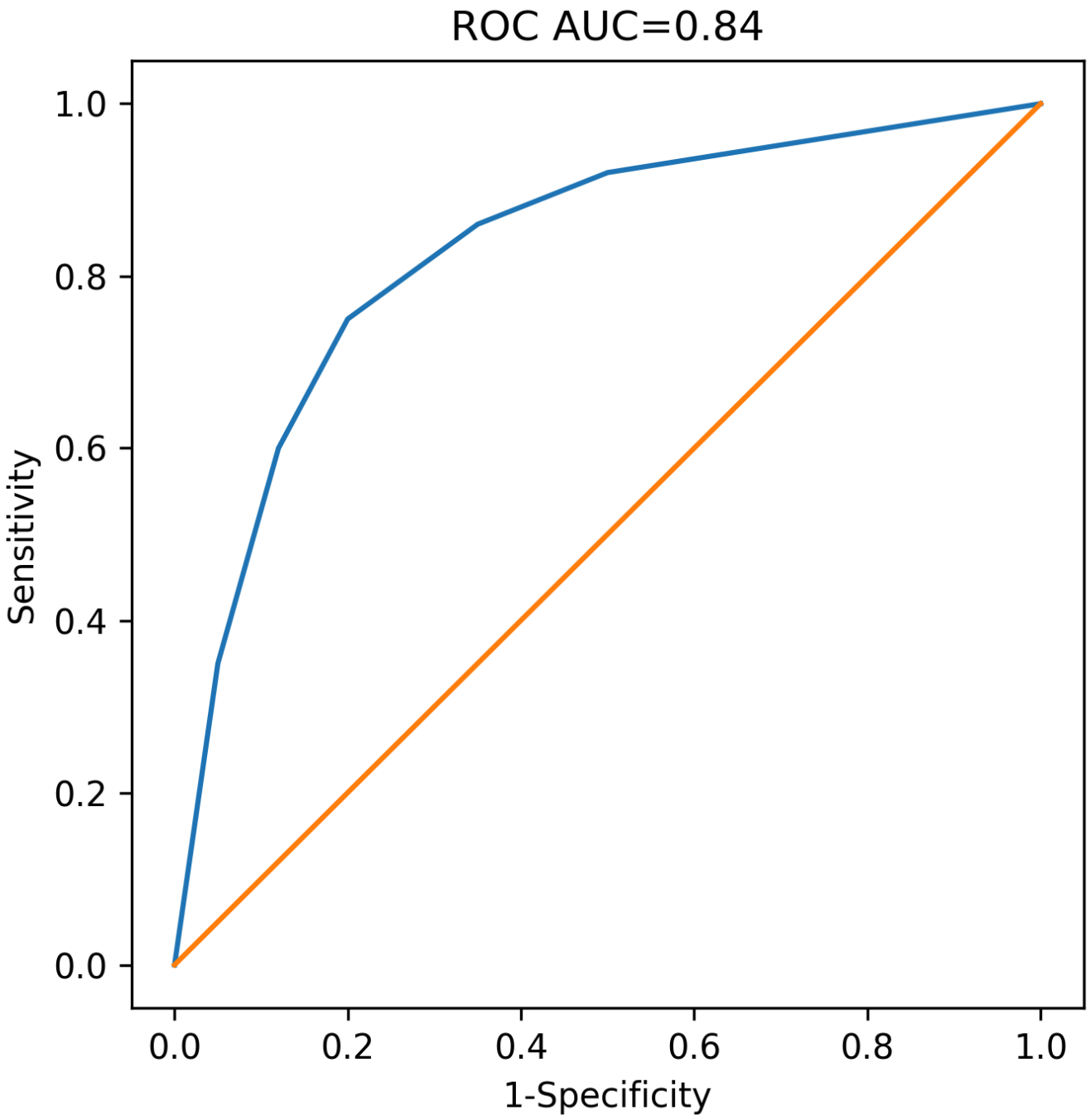


Figure 2

ROC curve showing the predictive performance of early postoperative TVR for long-term growth failure (AUC = 0.84; 95% CI, 0.72-0.96).

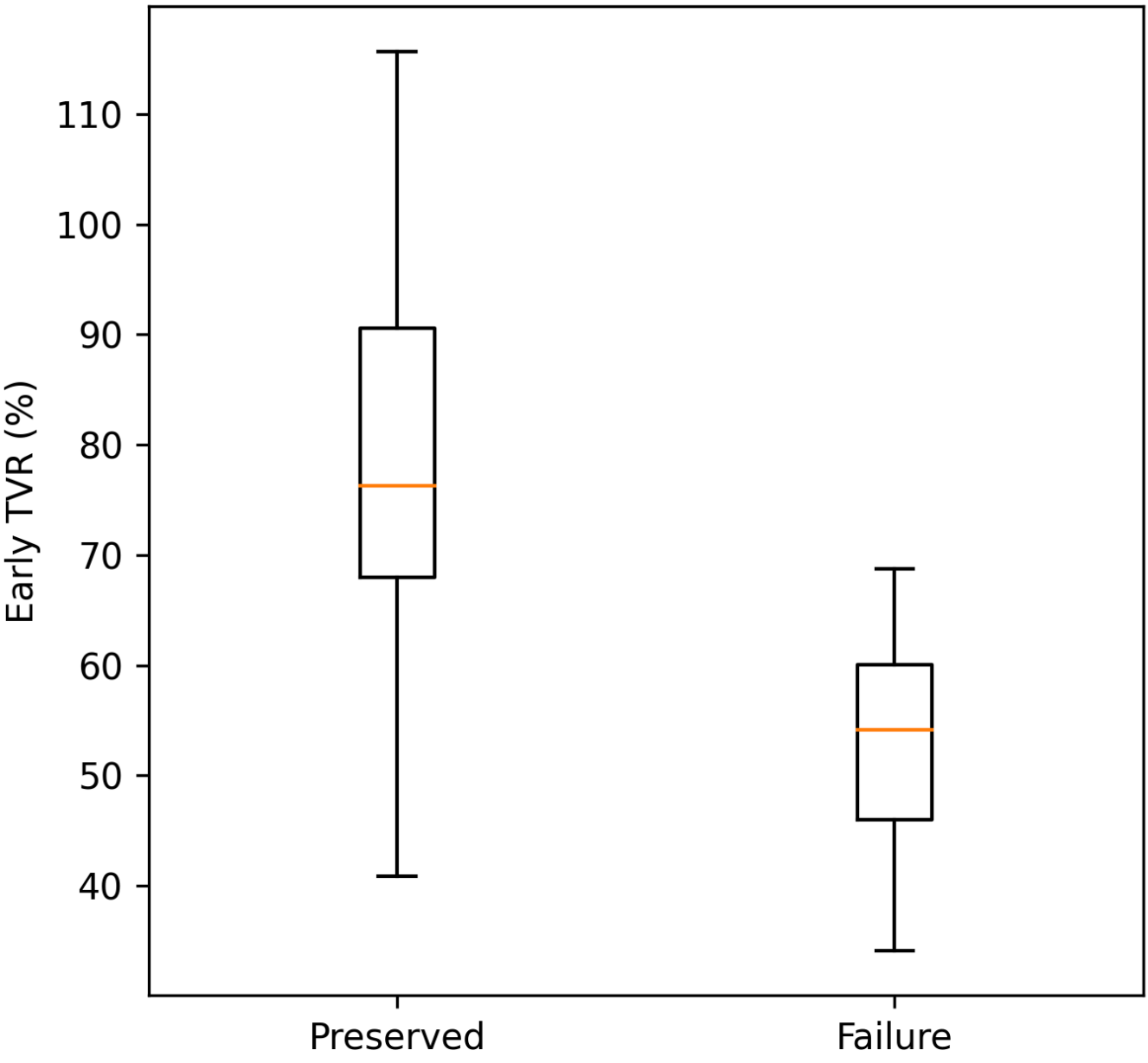


Figure 3

Distribution of early postoperative TVR according to long-term growth outcome.

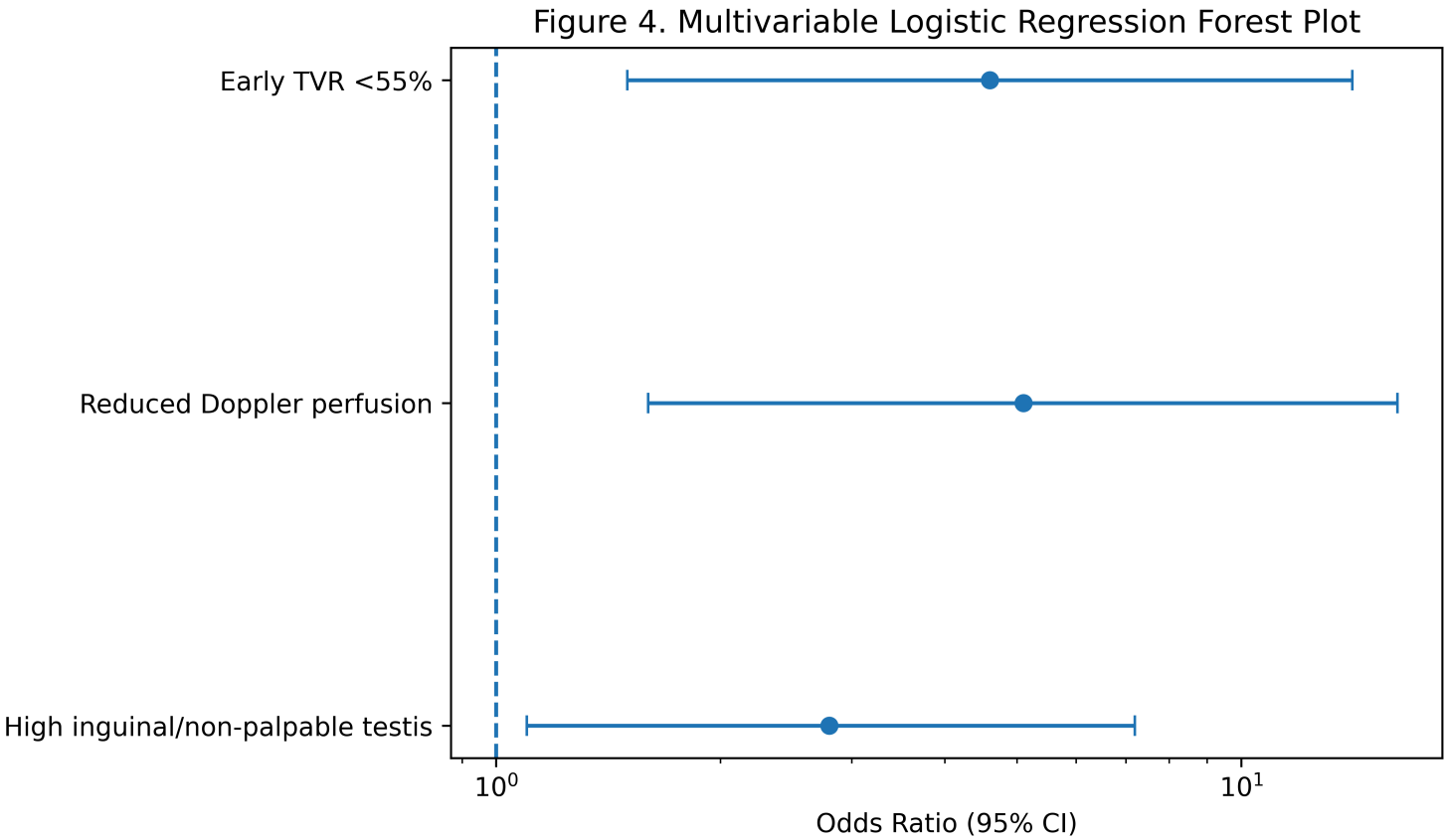


Figure 4

Forest plot of independent predictors of long-term growth failure following unilateral redo orchiopexy.