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Laser Doppler spectroscopy of testes after unilateral orchiopexy

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Summary

Objective
Undescended testes are the most common urogenital malformation in boys. Impaired microcirculation is among other factors addressed as a potential complication of surgery and scar formation, leading to long-term suboptimal results.

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Our aim was to compare the postoperative microcirculation in operated versus non-operated contralateral testis groups after unilateral orchiopexies versus a healthy control cohort.

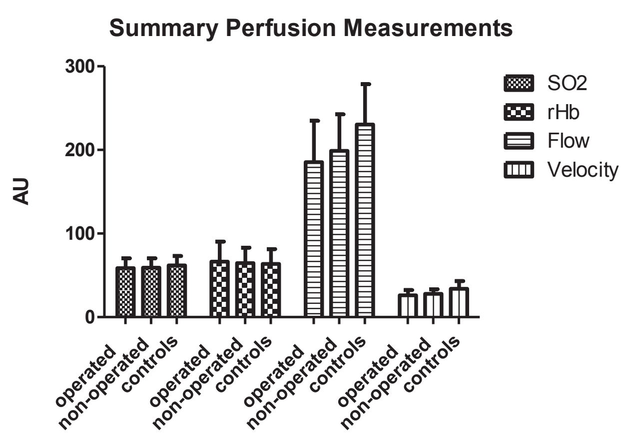
Methods
Ninety-nine consecutive patients were included after unilateral orchiopexy procedures at the age of 3.5 years (±2.9 years) at a single center for pediatric surgery. Eight-five patients were examined with a combination of laser Doppler (blood flow determination) and white-light spectroscopy (oxygen saturation and hemoglobin amount determinations) to determine the microcirculation at two different depth levels non-invasively. All relevant surgery data were obtained retrospectively.

Results
The right side was operated in 53.5% of cases. Previous hormone treatment had been prescribed in 46.5%. There were no significant differences in perfusion measurements between patients with previous hormone therapy and patients without. There was no significant difference in age and clinical pubertal stage between groups; however, 65% of patients underwent surgery after their second birthday. When comparing oxygen saturation (So_2), relative hemoglobin (rHb), flow, and velocity in the operated testis with the contralateral testis of the same patients, we found significantly higher flows and velocities for the contralateral testes ($p = 0.041$, $p = 0.022$). Similar higher flows and velocities were found in the healthy controls ($p < 0.001$). The differences between healthy controls and contralateral testis that were not operated on did not reach statistical significance.

There was no difference in measurements at 2 mm depth (skin and subcutaneous tissue) between groups to rule out systemic or capillary differences.

Discussion
Important limitations include the limited and relatively heterogeneous samples that were obtained for follow-up and retrospective surgery data collection. An additional limitation is missing presurgical data, which we hope to obtain in future studies. Hormonal data or bone age could not be obtained for study reasons. The age in our study was on average above the recommended age for orchiopexy in Germany (6—12 months), which could also restrict generalizability. In terms of complications, we observed reascending testes within the range but a rather high incidence of wound infections. The combination of Doppler and white-light spectroscopy was easily applicable and produced reliable data at 2 and 8 mm depth simultaneously in a standardized setting.

Conclusions
After orchiopexy, differences were found in the microcirculation between the operated and contralateral testes or healthy controls. It remains unclear if this is an effect of primary disease or surgery. The microcirculation of contralateral testes was also seemingly different from controls. This is most likely not a consequence of surgery alone, but a common problem for both testes in the affected patients.



Figure

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Introduction

Undescended testis is the most common urogenital anomaly in newborns, whereby it affects 2–8% of all boys [1,2]. The pathogenesis is multifactorial and can be attributed partially to endocrine disruption [3], placental malfunction [4], genetic influences [5], and environmental factors [6,7]. The incidence of cryptorchidism is higher in preterm boys, but most patients will have descended testes at 40 weeks of gestational age [8].

The natural course, however, leads to impaired fertility and increased risk for malignancy [9].

In undescended testes, the germ cells are still observed at birth. The later the orchiopexy takes place, the lower the concentration of germ cells that are observed in biopsies [10]. A lower germ cell concentration is correlated with lower sperm counts in later adulthood [11].

In the United States alone, more than 25,000 orchiopexies are performed every year [12]. Complications include injury to the testes and funicular structures as well as the attached vessels and nerves. This can lead to impaired microcirculation, a decrease in cell regeneration, insufficient healing and, eventually, a lower germ cell count.

Our hypothesis is that after orchiopexy there is persistently decreased microcirculation in the affected testes compared with controls, which leads to hypotrophy and, possibly, later functional impairments.

The aim of our study was to compare the postoperative microcirculation in operated versus non-operated contralateral testes after unilateral orchiopexy versus a healthy control cohort.

Methods

Patients were included 6 months to 2 years post orchiopexy. All relevant data were obtained retrospectively from the patient records. The current perfusion levels were evaluated with laser Doppler and white light spectroscopy.

The controls were age-matched boys who visited the pediatric surgery outpatient clinic for non-testes-related problems. They had no history of undescended testes, no previous abdominal, inguinal, testicular, or scrotal operations.

All clinical evaluations, including initial indications for surgery, were performed by one of two experienced pediatric surgeons in the team.

Laser Doppler and white-light spectroscopy procedures were performed using the O2C device (LEA Medizintechnik, Germany, Vers 1212) simultaneously at depths of 2 mm and 8 mm.

The O2C measurement principle

The measurement method is a combination of a laser Doppler spectroscopy procedure for blood flow determination and a white-light spectroscopy procedure for oxygen saturation and hemoglobin amount determinations.

The laser light determines perfusion quantities in tissues, and the movement of erythrocytes causes a Doppler shift. This Doppler shift of the detected laser light is analyzed using the O2C device and is displayed as the blood flow velocity. The detected laser signal also correlates with the number of moving erythrocytes in the tissue. The O2C uses this together with the blood flow velocity to calculate the blood flow.

The O2C uses the white light for the detection of the hemoglobin parameters, which include oxygen saturation (So_2) and the relative hemoglobin (rHb). The tissue hemoglobin value is determined by the amount of light absorbed by the tissue. The greater the amount of blood contained in the measured volume, the more light will be absorbed by the hemoglobin, which is the strongest light absorber in tissue, and, correspondingly, less light will be detected by the sensor. The O2C calculates from the absorbed part of the relative hemoglobin amount for the illuminated tissue volume. This measurement represents the hemoglobin amount per tissue volume and is independent of the vessel density, vessel lumen level, and hemoglobin quantity in the blood [13,14].

This procedure allowed for the continuous measurement of regional hemoglobin (rHb), post-capillary So_2, and blood flow levels in our study at depths of 2 and 8 mm.

The So_2 parameter, or post-capillary O_2 saturation, is a measurement for oxygen extraction in the capillary region. Additionally, animal studies have proposed a risk of acute hypoxia if the So_2 is $<10\%$.

The device only measures light absorption in vessels $\leq 100\ \mu m$ [15].

Regional hemoglobin refers to the filling of capillary vessels, which is dependent on the hemoglobin concentration in the blood, the vessel diameter, and the proximity of the capillary vessels (measurements are in 0–120 arbitrary units [AU]).

Blood flow is the product of the erythrocyte number at a certain speed multiplied by the speed measured. Reference values in the healthy controls are between 10 and 50 AU on the arm or leg. Values below 5 are thought to be problematic [14].

O2C measurements were taken in a darkened room to avoid distracting light sources. The flexible probe was placed without pressure on the scrotal skin above the testis. Measurements were taken from both testes, and control values were also taken from a defined area on the upper leg. Fifteen measurements were taken every 2 s, and an average was calculated for further analysis.

Parent authorization was obtained before any examination for all of the study participants. Statistical significance was assumed at $p < 0.05$, statistical testing was performed with t tests or Mann–Whitney U tests, where appropriate, and with Wilcoxon-related pairs tests for intra-individual comparisons using Statistica 10 (StatSoft, Tulsa, OK, USA). The study size was estimated to be appropriate for expected effect sizes.

Results

Ninety-nine patients with consecutive follow-up visits were included after unilateral orchiopexies at the age of 3.5 years (±2.9 years, median 2.5 years). Inclusion criteria included orchiopexy within the last 5 years, maximum patient age 13 years, and minimal time of 6 months between surgery and follow-up.

Sixty-five percent underwent surgery after their second birthday. Four patients with intra-abdominal presurgical