Published in final edited form as:

J Pediatr Urol. 2014 April ; 10(2): 312–316. doi:10.1016/j.jpuro.2013.10.012.

Digital Photographic Measurement in Hypospadias: Validation and Comparison to Intraoperative Measurement

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Abstract

Background—We propose a standardized method of photographing the hypospadias penis to capture penile dimensions that may be relevant for surgery. We also validate the use of digital imaging software for calculating penile dimensions as a substitute for intraoperative caliper-based measurements.

Methods—Photographs were taken of hypospadias penises in four different views after placement of a traction stitch and retraction of the preputial hood. Intraoperative measurements were obtained with a caliper. Digital measurements were taken of the same parameters postoperatively. All measurements were obtained in triplicate by multiple participants, and averages were tested for equivalency by determining the correlation coefficient for each parameter. Inter-observer correlation was also calculated for each parameter.

Results—180 intraoperative and 180 digital measurements were taken from 60 dimensions on 10 hypospadiac penises. Strong correlation existed between most digital and intraoperative measurements. Average inter-observer correlations ranged from 0.91 to 0.99 for each of the intraoperative measurements, and 0.90 to 1.00 for each of the digital measurements.

Conclusions—Standardized imaging is effective in capturing penile dimensions and measurements during hypospadias surgery. When compared with intraoperative measurements,

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Ethical Approval

There was no ethical approval required for this study. The study was approved by the University of Washington Institutional Review Board (IRB 14595).

Conflict of interest

None.

digital measurements are reliable and precise; digital photography has the potential to both aid in surgical planning and improve documentation.

Keywords

Hypospadias; Photography; Digital Measurements; Standardization

Introduction

With an incidence of 0.4% in the USA, hypospadias is one of the most prevalent conditions treated by pediatric urologists [1]. Despite this frequency, there is a lack of high-quality, reproducible outcomes data. The reason is likely, in part, because of the overall heterogeneity of hypospadias penises as well as the lack of an objective standardized assessment protocol. No two hypospadias penises are identical; without a standardized method of quantifying and documenting discrete characteristics of patients' penises, the literature on hypospadias outcomes has limited generalizability and practitioners have struggled to determine which published outcome is applicable to each unique patient [2–4,5].

To document penile anatomy and standardize measurements, our group has utilized digital photography as a substitute for intraoperative measurements. In this pilot study, we propose and evaluate a standardized protocol for photographing the hypospadias penis and use computer-based image software to digitally measure penile dimensions; digital measurements were assessed for reliability among users and validated by comparing values with intraoperative caliper-based measurements.

Materials and methods

Institutional review board approval was obtained (IRB 14595). All patients undergoing hypospadias repair between September, 2012 and January, 2013 at our institution were eligible for inclusion. Patients who had undergone prior hypospadias repair were excluded. Prior to photography, all patients were induced under general anesthesia and placed in the supine position. All children were surgically sterilized and draped according to standard surgical practice. Photographs were taken of the penis in four different views following retraction of the preputial hood and placement of a traction stitch in the glans penis. Views included: ventral stretched penis (Fig. 1); ventral with the urethral plate spread wide (Fig. 2); from above the tip of the glans (Fig. 3); side of the stretched penis (Fig. 4). A single camera, the 12.1 megapixel PowerShot SD1300 IS digital camera (Canon, Tokyo, Japan) was used for all photographs. During photography, the camera was held 6 inches away from the penis; all external overhead spot-lighting was aimed away from the field of view. No zoom or flash was used. A ruler and caliper (Aesculap, Center Valley, PA, USA) were included in each photograph as size references. Immediately following each photograph, the following measurements were obtained with the caliper in triplicate using three blinded scorers: glans height (Fig. 1), urethral plate width and length (Fig. 2), and glans width and depth (Fig. 3). Penile length was obtained using a ruler (Fig. 4). Scorers included urology attendings, trainees, and medical student volunteers.

Postoperatively, the images were uploaded to a computer, where three blinded scorers used the freeware software ImageJ (Bethesda, MD, USA) to obtain digital measurements of the same parameters, also in triplicate. Measurements were determined by setting a reference measurement of 1 cm to the distance between tips of the calipers in each photograph, and then using the mouse to select the dimension of interest. Digital scorers were blinded to intraoperative values. Averages of the digital and intraoperative measurements were tested for equivalency by determining the correlation coefficient for each parameter (Stata v12, College Station, TX, USA). Inter-observer correlation was determined between the three raters and averaged for each of the measurements. Strong correlation was defined as $R > 0.65$.

Results

Patient characteristics

The mean (range) age of subjects was 1.9 years (0.58–9.45). In all cases, surgery was performed by one of four surgeons. Following degloving, meatus location was glanular in two, distal shaft in six, and penoscrotal in two. All patients were photographed immediately prior to primary, one stage repair Snodgrass TIP or Thiersch-Duplay repair. No patients had a disorder of sexual differentiation diagnosis.

Imaging

A total of 180 intraoperative and 180 digital measurements were taken from 60 dimensions on 10 penises with hypospadias undergoing primary repair. Actual and digital measurements are presented in Table 1. Strong correlation existed between digital and intraoperative measurements of the glans width, glans depth, urethral plate width, urethral plate length, and penile length ($R = 0.95, 0.68, 0.97, 0.96, 0.93$, respectively). Glans height measurements were not as strongly associated with intraoperative measurements ($R = 0.57$).

Inter-observer reliability

Table 2 depicts the inter-observer correlation between the raters averaged for each of the penile dimensions for both intraoperative and digital measurements. The reliability of measurements was high between the raters; average inter-observer correlation ranged from 0.91 to 0.99 for each of the intraoperative measurements, and 0.90 to 1.00 for each of the digital measurements.

Discussion

In the plastic surgery and dermatology literature, the role of photography is well documented [6]. Authors have addressed guidelines for the use of imaging in both medical documentation and surgical planning [7]. Optimal imaging and lighting parameters have also been defined to help standardize photography [8,9]. However, the field of pediatric urology has yet to adopt photographic assessment as a standard or routine practice for hypospadias management.

Prior authors have described the utility of photography in the management of hypospadias. In 2001, Baskin reported his use of photography in documenting and assessing outcomes in over 180 patients undergoing hypospadias repair [10]. Similarly, Weber and colleagues proposed a standardized photographic Penile Perception Score for postoperative assessment following hypospadias repair [10]. However, continued widespread adoption of the technology is lacking among hypospadiologists.

Hypospadias is particularly well suited for photographic assessment. If a picture is worth a thousand words, digital imaging is invaluable in documenting the subtle characteristics of a particular hypospadias penis. This is particularly relevant in the era of electronic medical servers, where there is already a secure method of storing digital images in the patient's electronic chart. However, if photography is to be incorporated into the formal evaluation of hypospadias, standardization is critical to ensure that all relevant penile variables are captured comprehensively, accurately, and adequately. Additionally, such standardization would allow for improved reporting of baseline values and outcomes in multi-institutional studies.

We hope that this pilot study will incite future studies to use standardized measurements to analyze outcomes as a function of penile, glans, and urethral parameters. To date, only glans width, urethral plate width, and meatus location have been formally evaluated [11–13]; to our knowledge there has been no analysis of surgical outcome as a function of glans height, depth, or penile length. We chose glans height and depth as suggested variables for future studies as our anecdotal evidence suggests these parameters to be associated with glans retraction. However, the purpose of this manuscript was not to validate the utility of measuring specific penile dimensions, but rather to demonstrate that multiple valid measurements can be obtained through standardized digital imaging. Another advantage of digital evaluation is that it also allows for the assessment of nonlinear measurements, such as glans area, glans circumference, and penile angulation, dimensions difficult to capture in real time that may also correlate with hypospadias outcomes. We encourage future studies to correlate these suggested penile dimensions with clinical outcomes using our suggested standardized digital measurement protocol.

Our results suggest that digital photographic measurements can substitute for intraoperative measurements of glans width, glans depth, penile length, urethral plate width, and urethral plate length. Digital glans height measurements did not correlate as well with intraoperative findings. The reasons for this are unclear; it is possible that variations in tension placed on the glans suture may have altered the measurements. Additionally, it should be noted that the inter-observer correlation was also poorest for glans height. Given this finding, the ventral stretched penis image (Fig. 1) has limited utility and we do not advocate its routine use. Thus a practitioner trying to minimize imaging time may be able to capture the majority of relevant penile measurements through two images: ventral view with urethral plate spread wide (Fig. 2) and above the tip of the glans (Fig. 3).

Digital measurements of glans depth were also not as highly correlated with intraoperative measurements. The reason for this is likely to be because of variations in the horizontal plane where the measurements were made intraoperatively. The glans is not reliably conical

and its widest dorsoventral point is not always the base. Some glans extend most ventrally towards the tip. Digital images only capture the widest point, regardless of its position on the glans. This discrepancy may explain the relatively lower R value for glans depth.

Surgical planning is often dependent on penile and urethral characteristics; however, preoperative measurements are often tedious and difficult to obtain in children. Although our study only investigated intraoperative digital imaging, it would stand to reason that preoperative digital imaging may also have utility in surgical planning. Of course, this would require separation of physiological preputial adhesions stretching the penis without a glans stitch first. More importantly, such preoperative imaging may allow surgeons to discuss subtle variations in penile anatomy with families and trainees to help explain reasons behind surgical technique selection and potential complications.

Conclusions

We propose a standardized method of photographing and assessing the hypospadias penis. Our results suggest that digital measurements can substitute for intraoperative measurements. Standardized photography has the potential to improve documentation and aid in future outcomes studies; however, this manuscript serves as the first proof-of-principle, as further studies are needed before the true utility of digital photography is determined.

Acknowledgments

We acknowledge funding for this project was provided by the DSD-Translational Research Network (NIH Grant 5R01 HD068138).

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Figure 1.
Ventral stretched penis view. Glans height is measured from the midline of the distal mucosal collar to the tip of the penis.

Figure 2.

Ventral stretched penis with urethra spread wide view. The glans is pinched and retracted maximally. The urethral plate length is measured from the urethral meatus to the tip of the plate. The urethral plate width is measured as the widest point on the exposed urethral plate.

Figure 3.

Tip of glans view. The penis is stretched perpendicularly anterior and a straight-on image of the tip of the penis is obtained. The glans width and depth are measured as the widest points in each dimension.

Figure 4.

Side of the stretched penis. The penis is stretched perpendicularly anterior and a side shot of the penis is obtained. The penile length is measured from the crease at the base of the pubis to the tip of the glans.

Table 1

Actual and digital measurements of penile and urethral dimensions.

Dimension	Actual measurements (cm)		Digital measurements (cm)		<i>R</i>
	Average	Range	Average	Range	
Glans height	1.06	0.80–1.30	1.02	0.8–1.25	0.57
Urethral plate width	0.47	0.20–0.90	0.45	0.2–0.85	0.97
Urethral plate length	1.08	0.20–2.00	0.98	0.25–1.63	0.96
Glans width	1.33	0.80–2.00	1.27	0.86–1.68	0.95
Glans depth	1.16	0.80–2.00	1.04	0.81–1.4	0.68
Penile length	3.83	2.70–5.00	3.92	2.21–5.61	0.93

Table 2

Average inter-observer correlation (IOC) by penile dimension for intraoperative and digital measurements between three raters.

Dimension	Average IOC of intraoperative measurements	Average IOC of digital measurements
Glans height	0.91	0.90
Urethral plate width	0.97	0.96
Urethral plate length	0.97	1.00
Glans width	0.99	0.97
Glans depth	0.97	0.97
Penile length	0.99	0.98