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Three-Dimensional Photography for Quantitative Assessment of Penile Volume-Loss Deformities in Peyronie's Disease

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ABSTRACT

Background: Non-curvature penile deformities are prevalent and bothersome manifestations of Peyronie's disease (PD), but the quantitative metrics that are currently used to describe these deformities are inadequate and non-standardized, presenting a barrier to clinical research and patient care.

Aim: To introduce erect penile volume (EPV) and percentage of erect penile volume loss (percent EPVL) as novel metrics that provide detailed quantitative information about non-curvature penile deformities and to study the feasibility and reliability of three-dimensional (3D) photography for measurement of quantitative penile parameters.

Methods: We constructed seven penis models simulating deformities found in PD. The 3D photographs of each model were captured in triplicate by four observers using a 3D camera. Computer software was used to generate automated measurements of EPV, percent EPVL, penile length, minimum circumference, maximum circumference, and angle of curvature. The automated measurements were statistically compared with measurements obtained using water-displacement experiments, a tape measure, and a goniometer.

Outcomes: Accuracy of 3D photography for average measurements of all parameters compared with manual measurements; inter-test, intra-observer, and inter-observer reliabilities of EPV and percent EPVL measurements as assessed by the intraclass correlation coefficient.

Results: The 3D images were captured in a median of 52 seconds (interquartile range = 45−61). On average, 3D photography was accurate to within 0.3% for measurement of penile length. It overestimated maximum and minimum circumferences by averages of 4.2% and 1.6%, respectively; overestimated EPV by an average of 7.1%; and underestimated percent EPVL by an average of 1.9%. All inter-test, inter-observer, and intra-observer intraclass correlation coefficients for EPV and percent EPVL measurements were greater than 0.75, reflective of excellent methodologic reliability.

Clinical Translation: By providing highly descriptive and reliable measurements of penile parameters, 3D photography can empower researchers to better study volume-loss deformities in PD and enable clinicians to offer improved clinical assessment, communication, and documentation.

Strengths and Limitations: This is the first study to apply 3D photography to the assessment of PD and to accurately measure the novel parameters of EPV and percent EPVL. This proof-of-concept study is limited by the lack of data in human subjects, which could present additional challenges in obtaining reliable measurements.

Conclusion: EPV and percent EPVL are novel metrics that can be quickly, accurately, and reliably measured using computational analysis of 3D photographs and can be useful in describing non-curvature volume-loss deformities resulting from PD. **Margolin EJ, Mlynarczyk CM, Muhall JP, et al. Three-Dimensional Photography for Quantitative Assessment of Penile Volume-Loss Deformities in Peyronie's Disease. J Sex Med 2017;XX:XXX−XXX.**

Key Words: Peyronie's Disease; 3D Photography; Penile Volume

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INTRODUCTION

Peyronie's disease (PD) is an acquired fibrotic disease of the tunica albuginea that can cause a range of penile deformitties.[1] Although penile curvature is the most classic manifestation, there are many other changes in morphology that can result from PD including unilateral indentations, bilateral indentations typically referred to as hourglass deformities, and proximal or distal tapering of the penis. These non-curvature deformities result in focal or global loss of erect penile volume (EPV) and can occur with or without penile curvature.

Currently, there is no standardized system for quantitative description of penile volume-loss deformities in men with PD. Penile length and circumference have been studied to a limited extent in these patients,[2,3] but these parameters are only minimally descriptive and can be difficult to reproduce and interpret.[4] The paucity of objective clinical parameters to describe non-curvature deformities limits our ability to understand the full impact of PD on affected patients and creates a challenge in studying the efficacy of available PD treatments on non-curvature deformities.

In this proof-of-concept study, we describe a method for quick and inexpensive acquisition of three-dimensional (3D) photographs of penises. We also describe a method for computational analysis of 3D photographs to generate highly descriptive quantitative metrics that can be used to describe penile deformity. We introduce the novel metrics of EPV and percentage of erect penile volume loss (percent EPVL). We also report on the accuracy and reliability of this method.

METHODS

Creation of Models

A free 3D computer graphics software program (Blender, Amsterdam, Netherlands) was used to create seven erect penis models: one with a normal shape and six with various deformities simulating those that can be found in patients with PD, including simple curvature, two hourglass varieties, unilateral indentation, distal taper, and proximal taper. All models were identical except in the deformed regions. The digital models were printed using a 3D printer to create physical models made of polylactic acid polymer (Figure 1A—G). All seven models had the same height (200 mm) and diameter at the base (85 mm). For the purpose of measurement, the proximal border of each model was set at 50 mm above the base.

Three-Dimensional Photography

Three-dimensional photography was used to capture images of each model. We used the Structure Sensor camera (Occipital, San Francisco, CA, USA) to capture detailed images in three dimensions. This 12- × 3- × 3-cm camera uses infrared light to capture the depth and contour of objects and works in conjunction with the camera on an iPad (Apple, Cupertino, CA, USA) to capture detailed 3D images in color. The images were obtained by moving the camera circumferentially around the model from a radius of 2 to 3 ft. The area of image capture was selected by adjusting the size of a box on the iPad screen. Each model was photographed in triplicate by four different observers (two attending urologists, one urology resident, and one medical student), resulting in 84 digital images. The images were transferred to a computer for analysis (Figure 1H—N).

Digital Measurements

The 3D images were analyzed using 3D computer graphics software. EPV, length, maximum circumference, and minimum circumference were measured for each image, and angle of curvature was measured for the curvature model. Length was measured along the ventral surface from the designated proximal border to the tip of the glans. Maximum and minimum circumferences were measured in the area of the shaft with the subjectively largest and smallest circumferences, respectively. EPV was generated by a fully automated function that is built into the program.

After obtaining all measurements, the images of the penises with volume-loss deformities were digitally reconstructed to create what they would look like without the deformities using the computer program's "sculpt" function (Figure 1O—U). The normal model and the curvature model were excluded from this step because they do not represent volume-loss deformities. The volume of the reconstructed model was used to calculate percent EPVL for each image by calculating the percentage of difference from the volume of the deformed model.

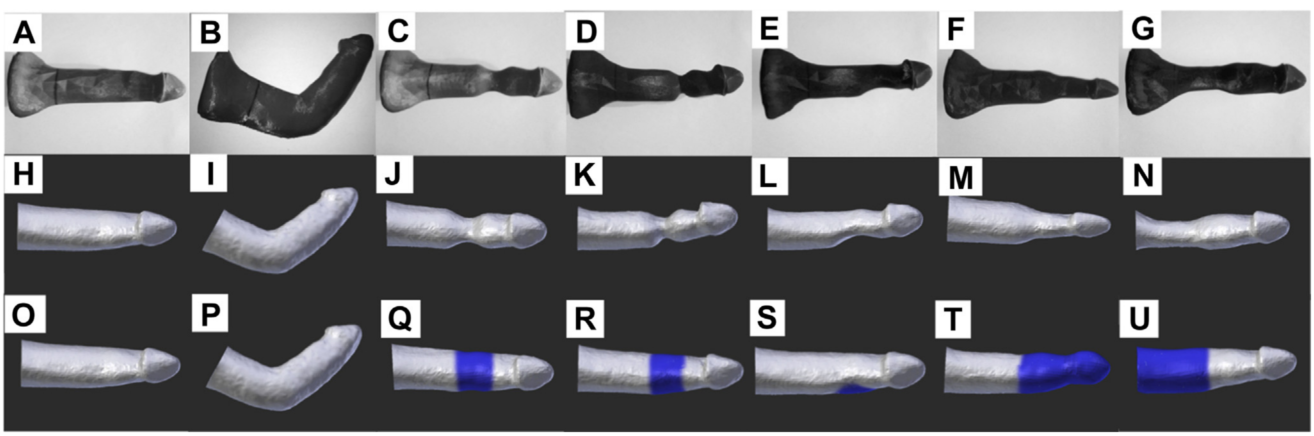

Figure 1. Panels A to G show standard two-dimensional photographs of penis models. Panels H to N show screenshots of three-dimensional photographs. Panels O to U show digitally reconstructed images, with shaded areas representing reconstructed segments (normal and simple curvature models were not reconstructed).