Normal Glanular and Meatal Measurements in Boys and Men

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OBJECTIVE To determine the normal vertical urethral meatus length (ML), maximum glanular width (MGW), the glanular seam length (between the lowest edge of urethral meatus and the glans closure line corona) (GSL) and GSL/ML ratio in all age groups.

MATERIALS AND METHODS Consecutive patients presented to urology and pediatric urology outpatient clinics were included in the study. Penile abnormalities, known endocrinological disorders, history of penile/urethral surgery were excluded. MGW, ML, and GSL were measured with a caliper. Glanular and meatal measurements were compared according to ages.

RESULTS A total of 1398 boys and men (380 (27.18%) prepubertal (1-12), 203 (14.52%) adolescent (13-19), and 815 (58.30%) postpubertal (19-93)) with a median age of 31 years (range: 1-93) were included in the study. In consecutive age groups, ML and GSL gradually increased and became steady between 16-19 & 20-30 age groups and 10-12 & 13-15 age groups, respectively. On the other hand, MGW gradually increased until 20 years of age and became steady at median of 35 mm over 20 years of age. Another interesting finding was a rather stable GSL/ML ratio in all age groups. Pairwise comparison of different age groups seemed to be similar and suggests a fixed ratio of 1.33 (IQR: 0.6).

CONCLUSION The normal glanular and meatal measurements may guide the surgeons for better cosmetic results during hypospadias repair. The GSL/ML ratio appears to be a stable measure for all ages to achieve better cosmetic results. UROLOGY 00: 1−6, 2023. © 2023 Elsevier Inc.

Hypospadias is one of the most common congenital anomalies in boys, with an incidence of 1 in 150-300 live births.[1] A normal glans, a functional urethra that opens to its normal position on the glans, and a penis without chordee can be counted among the goals of hypospadias repair. In hypospadias, where more than 300 known surgical methods have been described, complication rates of up to 27% have been reported, even in TIP repair, which is one of the most commonly used methods today.[2] These rates point out that the ideal repair method has not been reached yet. We consider that penile anthropometric measurements and ratios in children may contribute to cosmetic outcomes of penile surgeries particularly hypospadias. However, it is known that there is not sufficient data in the literature on penile anthropometric landmarks.

Hutten K and Babu R reported a mean meatal length of 5.4 mm and ventral glans length of 4.7 mm and found that the length was associated with age in children aged 0-15 years.[3] Similarly, another study reported that glans diameters, ventral glans length, and stretched penis length showed age-dependent changes, but the glans ratios did not.[4] To our knowledge, there was not enough data on meatal lengths, glans diameters, and ratios in serial pre- and postpubertal ages in the literature. Therefore, we aimed to determine the normal vertical urethral meatus length (ML), maximum glanular width (MGW), the glanular seam length (between the lowest edge of urethral meatus and glans closure line) (GSL), and GSL/ML ratio in different age groups of both pediatric and adult population.

MATERIALS AND METHODS

Consecutive patients presented to urology and pediatric urology outpatient clinics were included in the study between January and June 2020. The ethical approval was obtained from the local ethics committee before the study (No: 09.2019.289) and the informed consent form was taken from the patients or caregivers. Penile abnormalities (hypospadias, epispadias, congenital curvature, megameatus, meatal stenosis, etc.), known endocrinological disorders (hypogonadism, bilateral undescended testis, Klinefelter syndrome, Kallmann syndrome, etc.), acute or

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Table 1. The number of subjects under 18 years of age and their ML, MGW, and GSL measurements

Age	*n*	ML (mm)		GSL (mm)		MGW (mm)	
		Median (Min-Max)	Mean (SD)	Median (Min-Max)	Mean (SD)	Median (Min-Max)	Mean (SD)
1	28	3 (2-4)	**2.86 (0.51)**	4 (3-5)	**3.76 (0.63)**	8 (6-11)	**8.14 (1.59)**
2	33	3 (2-8)	**3.64 (1.34)**	5 (3-7)	**4.97 (1.23)**	8 (5-13)	**8.55 (1.75)**
3	15	3 (3-5)	**3.47 (0.74)**	5 (3-11)	**5.73 (2.49)**	10 (7-20)	**11.00 (3.42)**
4	28	4 (3-5)	**3.82 (0.77)**	6 (3-8)	**5.79 (1.34)**	12 (7-20)	**12.00 (2.96)**
5	36	4 (3-6)	**4.39 (1.22)**	7 (4-15)	**7.22 (3.33)**	14 (8-18)	**13.31 (2.29)**
6	32	4 (2-7)	**4.34 (1.40)**	7 (3-13)	**7.28 (2.75)**	14 (9-21)	**13.59 (3.64)**
7	44	4 (2-9)	**4.80 (1.62)**	8 (4-19)	**8.95 (3.84)**	15 (9-22)	**15.16 (3.24)**
8	36	5 (2-9)	**5.19 (1.86)**	6.5 (4-15)	**7.53 (3.23)**	14 (5-24)	**15.19 (5.07)**
9	30	5 (3-8)	**5.03 (1.73)**	6 (4-12)	**6.93 (2.34)**	16.5 (8-23)	**16.47 (4.32)**
10	30	5.5 (4-14)	**6.43 (3.04)**	9.5 (5-19)	**10.27 (4.50)**	20 (14-30)	**20.30 (4.13)**
11	35	6 (4-11)	**6.89 (2.13)**	11 (4-14)	**10.34 (2.97)**	20 (12-31)	**20.09 (5.03)**
12	33	7 (3-14)	**7.42 (2.78)**	12 (4-18)	**10.94 (4.10)**	21 (13-30)	**21.36 (5.27)**
13	27	9 (3-12)	**8.15 (2.71)**	13 (5-23)	**12.67 (4.57)**	24 (13-30)	**23.74 (4.98)**
14	27	7 (4-8)	**7.85 (2.03)**	10 (4-16)	**10.37 (3.62)**	24 (16-35)	**24.85 (5.37)**
15	44	8 (4-17)	**8.91 (2.94)**	12 (5-23)	**12.09 (3.97)**	26 (16-40)	**26.45 (5.11)**
16	37	10 (6-14)	**9.59 (2.40)**	12 (6-18)	**12.35 (2.85)**	28 (20-36)	**26.95 (4.41)**
17	47	10 (6-13)	**10.11 (2.06)**	13 (6-24)	**12.89 (3.35)**	28 (21-37)	**29.36 (4.42)**
18	15	10 (6-14)	**9.60 (2.61)**	14 (10-30)	**15.60 (5.19)**	29 (15-41)	**29.33 (8.12)**

GSL, the glanular seam length; MGW, maximum glanular width; ML, meatus length.

chronic penile disease (balanoposthitis, balanitis xerotica obliterans, Peyronie disease, priapism, lichen sclerosis, etc.), syndromic patients, children with nonretractile preputium, premature children, history of penile/urethral surgery were excluded from the study. Patients' weight, height and ages were recorded. A caliper was used to measure ML, GSL, MGW. ML measurements were made from the highest point of the urethral meatus to the lowest point.[3,5] The distance between the lowest point of the meatus and the glans closure line was measured for GSL. MGW was measured by considering the widest glans diameter from the corona level. All measurements were performed on flaccid penis at room temperature in the supine position. The measurements were obtained by 3 urology residents (OCO, MYS, YEG; one of them is a final year resident, the others are third year). Prior to the study, all 3 received standard training on measurements. Subjects were divided according to age (years) groups as 1-3, 4-6, 7-9, 10-12, 13-15, 16-19, 20-30, >30, and anthropometric glanular and meatal measurements were compared.

Statistical Analyses

Data were analyzed using the IBM Statistical Package for the Social Sciences version 29.0.0.0 (241) (IBM SPSS Statistics for Windows, Chicago, IL). The normality of the distribution of the variables was evaluated using the Shapiro-Wilk test. As the distribution of continuous variables did not provide a normal distribution, continuous data were presented with median, minimum and maximum. Independent groups were compared with Kruskal-Wallis test. Post hoc analysis was performed with Tamhane's T2. The *P* value <.05 was accepted as statistically significant.

RESULTS

A total of 1398 boys and men (380 (27.18%) prepubertal (1-12), 203 (14.52%) adolescent (13-19), and 815 (58.30%) postpubertal (19-93)) with a median age of 31 years (range: 1-93) were included in the study. The number of subjects under 18 years of age and their ML, MGW, and GSL measurements are shown in Table 1. While there was a significant difference between ML, MGW and GSL between age groups (P <.001, P <.001, P <.001), interestingly there was no difference between the groups for GSL/ML ratio (P = .09) (Table 2) (Figs. 1-2). The GSL/ML ratio was stable for all ages, and it was found to be 1.33 ± 0.92 for all subjects (Fig. 2). In post hoc analysis (Tamhane's T2), we found that ML, MGW, and GSL did not variate in some certain age groups. In consecutive age groups, ML and GSL gradually increased and became steady between 16-19 & 20-30 age groups and 10-12 & 13-15 age groups, respectively (Table 2) (Fig. 1). On the other hand, MGW gradually increased until 20 years of age and became steady at median of 35 mm over 20 years of age (Table 2) (Fig. 2).

DISCUSSION

Well-defined penile anthropometric measurements and ratios may contribute to better results in hypospadias surgeries, both functionally and cosmetically. However, there is not enough information on the subject in the literature. Although there are some low patient volume studies on the location of the urethral meatus on the glans and penile lengths and diameters,[3,6,7] there are no studies showing the relationship of anthropometric measurements in preadolescent, adolescent, and adult periods to the best of our knowledge. The present study showed that ML, GSL, and MGW values increased up to a certain age and then remained stable, and the GSL/ML ratio was similar at all ages. We consider that with a mean rate of 1.33, GSL/ML can be a guide during hypospadias repair in all age groups and it can be a golden ratio of penile anatomy.

One of the first studies on the length of the external urethral meatus in children was reported in 2007 by Hutton KAR and Babu R.[3] In the measurements performed on 75 children with a mean age of 6.9 (range 0.3-15) years, the mean meatal length was 5.4 mm and the ventral glans length was 4.7 mm. In the same study, it has also

Table 2. Comparison of vertical meatus length (ML), glanular seam length (GSL), maximum glans width (MGW), and GSL/ML in age groups

Age Groups	*N*	ML (mm) Median, (95% CI) Mean (SD)	GSL (mm) Median, (95% CI) Mean (SD)	MGW (mm) Median, (95% CI) Mean (SD)	GSL/ML Ratio Median, (95% CI) Mean (SD)
1-3	76	3 (3.08-3.55) **3.31 (1.04)**	4 (4.30-5.02) **4.66 (1.58)**	8 (8.34-9.40) **8.87 (2.35)**	1.33 (1.35-1.62) **1.49 (0.58)**
4-6	96	4 (3.97-4.45) **4.21 (1.19)**	6 (6.27-7.38) **6.82 (2.74)**	14 (12.41-13.64) **13.02 (3.03)**	1.50 (1.58-2.02) **1.80 (1.10)**
7-9	110	5 (4.66-5.32) **4.99 (1.72)**	7 (7.30-8.57) **7.94 (3.37)**	15 (14.73-16.32) **15.53 (4.20)**	1.50 (1.58-2.00) **1.79 (1.09)**
10-12	98	6 (6.39-7.46) **6.93 (2.66)**	11 (9.75-11.29) **10.52 (3.84)**	20 (19.61-21.55) **20.58 (4.84)**	1.42 (1.51-1.79) **1.65 (0.70)**
13-15	98	8 (7.87-8.94) **8.41 (2.67)**	12 (10.95-12.60) **11.78 (4.11)**	26 (24.22-26.31) **25.27 (5.22)**	1.37 (1.31-1.53) **1.52 (0.77)**
16-19	105	10 (9.29-10.21) **9.75 (2.37)**	13 (12.49-13.95) **13.22 (3.78)**	29 (27.54-29.68) **28.61 (5.52)**	1.28 (1.25-1.38) **1.42 (0.56)**
20-30	105	10 (9.14-10.18) **9.66 (2.68)**	13 (13.75-14.37) **14.74 (5.15)**	35 (32.94-35.17) **34.06 (5.74)**	1.30 (1.50-1.92) **1.71 (1.09)**
>30	710	10 (10.13-10.51) **10.32 (2.57)**	13 (14.46-15.21) **14.83 (5.09)**	36 (34.74-35.53) **35.14 (5.37)**	1.28 (1.51-1.65) **1.58 (0.95)**
P value		**<.001**	**<.001**	**<.001**	.09

GSL, glanular seam length; GSL/ML, meatus length/glanular seam length; MGW, maximum glanular width; ML, meatus length.

been reported that both meatal and ventral glans length are associated with age, similar to our study. In another study in which 94 children with a mean age of 5.9 years participated, the mean meatal length was 5.3 mm and the ventral glans length was 4.8 mm, and the ratios were calculated as 1.1-1.3.[5] Differently, in this study which has a large study group than the others. While the measurements of 75 children aged 0-15 were recorded in Hutton and Babu's study, measurements were performed on 478 children in the same age group in the present study. Moreover, GSL was similarly found to be greater than ML in all age groups. Besides, another important difference is that these studies were conducted only in the pediatric age group and present study included not only children but also adults. Interestingly, similar results were obtained in the adult group, and we think that this is important for the consistency of the results. We consider that another factor that creates the difference in these anthropometric measurements may be ethnicity. However, as far as we know, there is no comparative study on penile anthropometric measurements in the literature.

Another issue related to penile anthropometry is the meatus localization. A study of 500 men evaluated the location of the urethral meatus on the glans (tip of the glans, mid third, proximal third-near the corona) and found that only 55% were located on the tip of the glans.[7] In the same study, distal hypospadias was detected in 3% of the patients. Interestingly, in another study with 1244 men, it was reported that the urethral meatus was located on the tip of the glans in 96.3% and the subcoronal meatus was not seen.[8] The authors stated that this variation may be due to the patient' profile differences between the 2 studies. Similarly, it was detected in the distal one-third of the glans in 94% of children with a mean age of 4.6 years.[6] In the present study, penile abnormalities were excluded in this study, so we did not evaluate meatus localization. It is known that the appearance of the glans after hypospadias repair is effective in the satisfaction of the physicians and the parents.[9] Therefore, achieving the GSL/ML ratio may increase this satisfaction. However, we think that these variations in anatomical measurements and ratios in studies may change expectations following the repair. At this point, our recommendation is to close the glans wings according to the GSL values shown in Table 2. For example, we think that providing a ventral glanular seam length of approximately 4 mm at 1-3 years of age, 7 mm at 7-9 years of age, and 12 mm at 13-15 years of age may contribute to repair as cosmetic. Another point where the results of the study can contribute is the selection of the diameters of the catheters used during surgery. Meatus lengths according to age groups can be taken into account during catheter selection. Also, it has been reported that the use of anatomical landmarks measured in healthy controls as a reference reduces complications such as urethra cutaneous fistula and meatal stenosis after hypospadias repair.[10]

Another important parameter in penile anthropometry measurements is the glans' diameter. A study conducted on 263 children (0-16 years) without genital anomalies reported that the glans dimensions showed an age-dependent change.[4] However, it was determined that the ratio of glans diameter and circumference did not change in age groups (0.49-0.53). The authors emphasized that penile anthropometry nomograms can provide preoperative objective evaluation for hypospadias, help in patient selection for hormonal therapy, and can be a criterion for postoperative cosmetic outcomes.[4] In a study comparing healthy children and children with distal or proximal hypospadias (median ages were 1, 9, 9 months, respectively, P <.0001), the maximum glans diameters were different between all 3 groups (14.3, 14.8, and 12.9 mm, P <.0001).[11] In the same study, it was reported that the

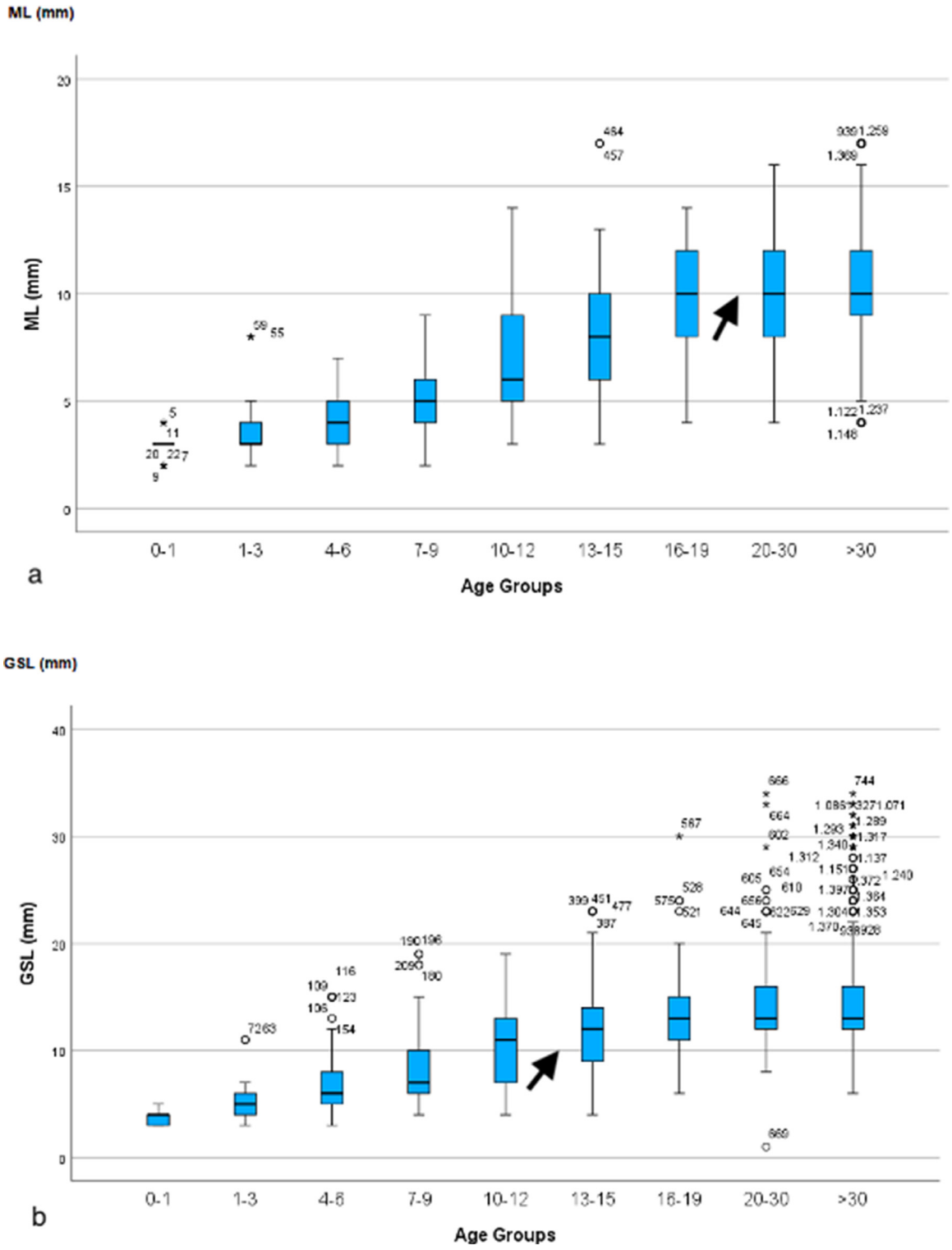

Figure 1. (**A**) The meatal lengths (ML) for age groups (P <.001 for multiple group analysis; the arrow indicates the age range in which the ML difference reaches stability). (**B**) The glanular seam lengths (GSL) for age groups (P <.001 for multiple group analysis; the arrow indicates the age range in which the GSL difference reaches stability).

glans diameter of newborns increased with age, but there was no correlation between glans diameter and age in children with distal or proximal hypospadias. Although the age of the control group was significantly lower in children with hypospadias, the glans' diameters were not lower. In a study evaluating children with hypospadias aged between 6 and 36 months, it was found that the glans' diameter decreased as the severity of hypospadias.[12] In addition, while there was no difference in glans diameters in children aged 6-24 months, a significant difference was found above 25 months. In the present study, the age-dependent change in the glans diameter was shown again

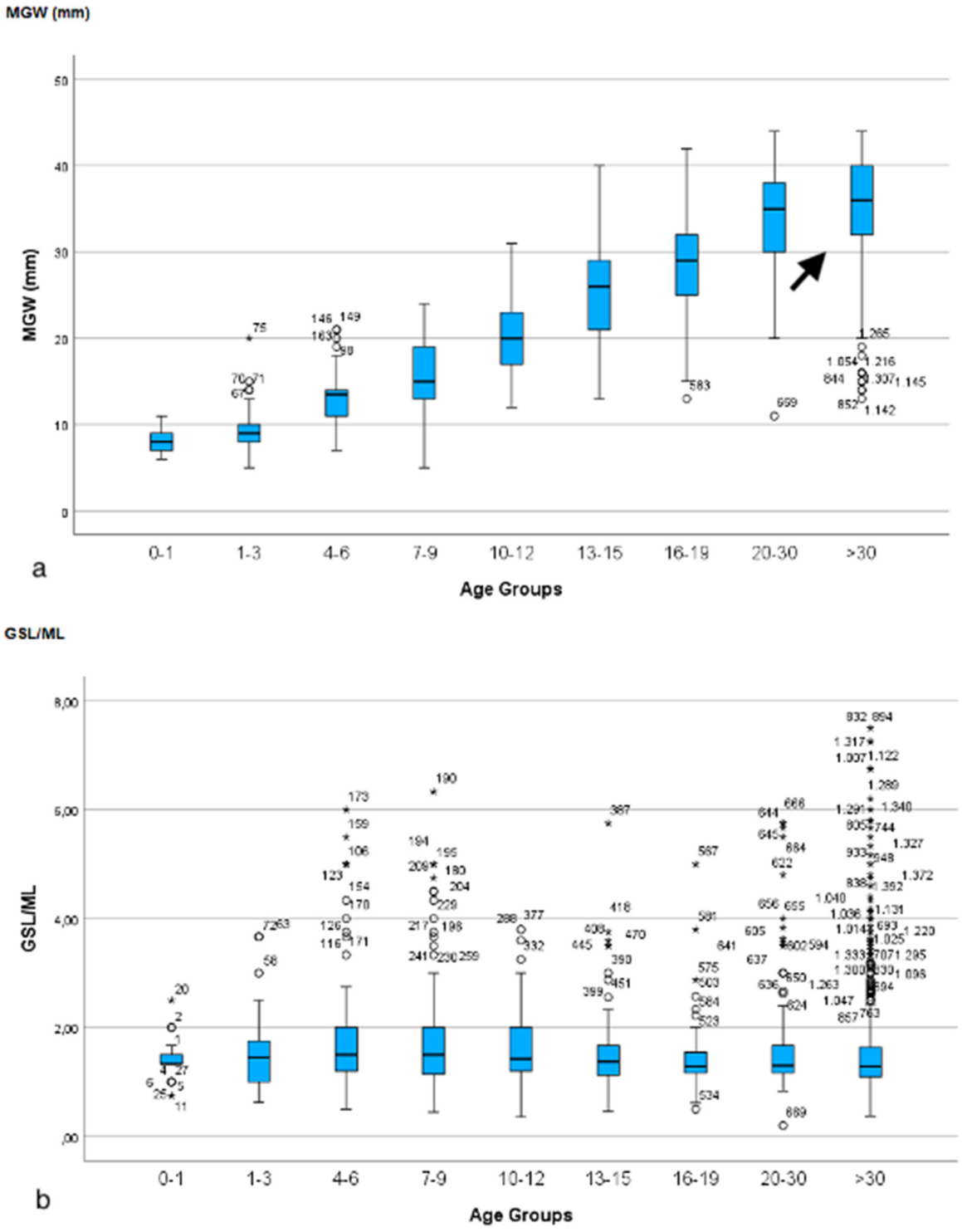

Figure 2. (**A**) The maximum glanular width (MGW) for age groups (P <.001 for multiple group analysis; the arrow indicates the age range in which the MGW difference reaches stability). (**B**) The GSL/ML ratio for age groups (P = .09 for multiple group analysis).

and it was determined for the first time that the glans diameter stabilized in the 20-30 age group. In addition, mean MGW was found to be 8.14 mm at age 1, 8.55 mm at age 2, 11.00 mm at age 3, and 12.00 mm at age 4 in this study. As mentioned before, we think that ethnicity may play a role in this difference.

The study has some limitations. Stretched or flaccid penile length and glans circumference were not measured. Only the GSL/ML ratio was evaluated. Other ratios related to the glans' diameter were not calculated. Since children without genital anomalies were included in the study, urethral meatus

localization was not evaluated. Tanner stage was not evaluated.

CONCLUSION

We believe that normal glanular and meatal anthropometric measurements according to age at different puberty stages will guide the surgeons for better cosmetic results at glanuloplasty and urethroplasty during hypospadias repair. Although ML, GSL, and MGW values stand out as reference values in age groups, we think that the GSL/ML ratio is a more stable measure to achieve better cosmetic results.

ETHICS OF APPROVAL STATEMENT

Ethical approval was obtained from the local ethics committee before the study (No: 09.2019.289).

PATIENT CONSENT STATEMENT

Available.

AUTHOR CONTRIBUTIONS

CAS: Concept-Design, Data interpretation, Manuscript drafting and writing, Statistical analysis, Literature screening; OCO: Data collecting; MYS: Data collecting; YEG: Data collecting; YT: Data interpretation, Statistical analysis; TT: Supervision; SY: Concept-Design, Data interpretation, Manuscript drafting and writing, Supervision.

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