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ANATOMICAL VARIATIONS OF KIDNEY BETWEEN PRONE, SUPINE AND SUPINE OBLIQUE POSITIONS USING CT UROGRAPHY: IMPLICATIONS FOR PERCUTANEOUS NEPHROSTOMY ACCESS

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ABSTRACT

Aim:

To compare anatomical parameters of the kidney between the prone, supine, and supine oblique positions and to find out the best position of the kidney from anatomical parameters for percutaneous nephrostomy access.

Materials and Methods:

The study was done among 50 patients who were referred to the radiology department (age > 18 years) for CT urography. In every patient, the unenhanced phase was done in the prone position, the nephrogenic phase was done in the supine position, and the pyelographic phase was done in the right supine oblique position, followed by the immediate delayed phase in the left supine oblique position, where only the kidneys were covered. Nephrostomy tract length, maximum renal access angle, and renal pelvis AP diameter were measured in prone, supine, and supine oblique positions.

Results:

We found that repeated measures ANOVA with a Greenhouse-Geisser correction determined that mean right nephrostomy tract length, left nephrostomy tract length, right maximum access angle, left maximum access angle, right renal pelvis AP diameter and left renal pelvis AP diameter differed statistically significant between supine, prone and supine oblique positions. However prone position earned reduction in nephrostomy tract length, increase in maximum access angle and renal pelvis AP diameter, which was statistically significant (p<0.001).

Conclusion:

The study found that the length of the nephrostomy tract was shorter, the maximum angle of access and the width of the renal pelvis in the anterior-posterior direction were greater in the prone position compared to the supine and supine oblique positions. This demonstrates that the prone position is optimal for percutaneous nephrostomy treatments.

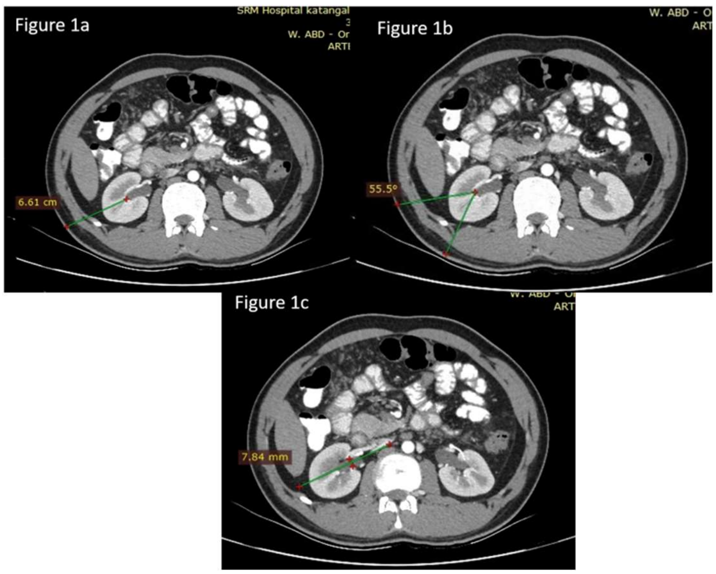
Keywords: Kidney; anatomy; position

INTRODUCTION:

Kidneys measure about 10–12 cm in length and 5–7 cm in width, with thickness varying from 3–5 cm. The position is usually found between the transverse processes of the T12 and L3 vertebrae and is located in the retroperitoneum. Both the upper poles usually show a slight medial orientation, and posterior orientation is noted in the lower poles. (1-4) Each kidney has a capsule around it, which in turn has Gerota's fascia, fat, and more fat(5). On a cross-section, the avascular plane of Brodel occurs between 2/3 anterior and 1/3 posterior of the kidney. This is where the anterior and posterior segmental renal artery branches meet. This makes it a pretty safe place to put in a nephrostomy into the pelvicalyceal system(6). Percutaneous Nephrostomy (PCN) is a technique in which percutaneous access to the kidney is achieved under radiological guidance (7). A percutaneous nephrostomy may be indicated as a treatment for urinary obstruction, urinary diversion, access to endourologic procedures, and diagnostic testing (antegrade pyelography, Whitaker test)(8). With the proper pre-procedure preparation, either with the patient in the prone, supine, oblique, or supine position, surface markings were done, and under USG guidance, the site of the percutaneous puncture was decided(9). After puncturing the appropriate site, a guidewire is inserted, the tract is dilated, and a nephrostomy tube is inserted over the guidewire. Either a malecot catheter or a pigtail catheter is used. Percutaneous nephrostomy access has been traditionally performed in the prone position. There are relative contraindications (compromised cardiorespiratory system) to the prone position, so few studies have suggested the supine position as an alternative technique. Since there are varied views regarding the best possible position for PCN access, the present study was proposed.

MATERIALS AND METHODS:

This cross-sectional study was conducted after the approval from our institutional ethical committee, and all patients provided their consent. The research was carried out on a cohort of 50 patients (aged over 18 years) who were referred to the radiodiagnosis department at SRM Medical College Hospital and Research Centre, Kattankulathur, for CT urography between January 2019 and June 2020.Patients who were referred for CT urography to the radiology department (age > 18 years) were included, and patients with anatomical renal abnormalities (e.g., ectopic kidney, horseshoe kidney), paediatric patients, patients contraindicated for CT (e.g., pregnancy), and patients with a previous history of renal surgeries were excluded. An Optima 660 GE 128 MDCT scanner was used, and non-ionic low-osmolar contrast was used for contrast administration. An extensive medical history was obtained from all patients, and then they underwent the unenhanced phase in the prone position, the nephrogenic phase in the supine position, a pyelographic phase in the right supine oblique position, and a delayed phase in the left supine oblique position that concentrated solely on the kidneys. Subsequently, the axial images were processed using the GE workstation, during which measurements were obtained for "nephrostomy tract length, maximum access angle, and renal pelvis AP diameter" in both the supine and prone positions of the kidneys.



NEPHROSTOMY TRACT LENGTH: This is measured from posterior calyx to skin edge along a plane in line with calyx’s infundibulum. **Figure 1(a)**

MAXIMUM ACCESS ANGLE: This is defined as angle between the lateral margin of paraspinous muscle and most posterior aspect of liver, spleen /colon. **Figure 1(b)**

RENAL PELVIS AP DIAMETER: It is the distance between anterior and posterior walls of renal pelvis measured tangentially to the renal pelvis. **Figure 1(c)**

Nephrostomy tract length, maximum renal access angle and renal pelvis AP diameter were measured in prone, supine and supine oblique positions.

STATISTICAL METHODS:

Descriptive Statistics: Continuous variables are represented in mean, median, mode and standard deviation. Categorical variables are represented in frequencies and percentages. Inferential Statistics: An ANOVA with repeated measures is used to compare three group means where the participants are the same in each group. P-values less than 0.05 were considered statistically significant. Data was entered in MS excel sheet and analyzed using SPSS software version 16.

RESULTS:

A total of 50 patients were included in the study. Age and sex distribution of the patients is given in [Table 1] respectively.A Greenhouse-Geisser correction determined that mean nephrostomy repeated ANOVA measures of tract length, maximum access angle, and renal pelvis AP diameter in different positions differed statistically significantly between supine, prone, and oblique positions (mean (SD) values given in Table 3); (F and p values given in [Table 4]. Post-hoc tests using the Bonferroni correction revealed that the prone position earned a reduction in nephrostomy tract length, maximum access angle, and renal pelvis AP diameter, which was statistically significant. (Table 4) (Fig 2a-4b) Shows associations that nephrostomy tract length was less, maximum access angle was higher, and renal pelvis AP diameter was higher in the prone position compared to the supine and oblique positions. This was statistically significant. This shows that the prone position is ideal for easy surgical manipulation.

Table 1: Demographic Characteristics of the study population, anatomical parameters

Study Population	48.98±14.14
Male%	22 (44.0%)
Female%	28 (56.0%)

Table 3: Demographic characteristic of Nephrostomy tract length, Maximum access angle and Renal pelvis AP diameter in different positions.

	Supine	Prone	Oblique
Right Nephrostomy tract length(cm)	6.93±1.69	5.99±0.6	6.36±1.03
Left Nephrostomy tract length (cm)	6.61±1.27	5.89±0.99	6.52±0.98
Right Maximum access angle (deg)	70.66±17.97	76.61±14.98	75.92±13.7
Left Maximum access angle(deg)	75.17±15.76	79.14±17.969	77.34±17.8
Right Renal Pelvis AP Diameter (mm)	10.41±3.99	11.27±4.46	9.29±3.46
Left Renal Pelvis AP Diameter (mm)	9.65±3.15	10.04±4.14	8.92±3.46

Table 4: Association of Nephrostomy tract length, Maximum access angle and Renal pelvis AP diameter in different positions

	F value	p value
Right Nephrostomy tract length	20.173	<0.001
Left Nephrostomy tract length	25.3	<0.001
Right Maximum access angle	3.36	0.032
Left Maximum access angle	4.46	0.02
Right Renal Pelvis AP Diameter	17.73	<0.001
Left Renal Pelvis AP Diameter	4.14	0.03

DISCUSSION:

Our study was done in 50 patients, but only 30 patients were included in the study done by Yazici et al[10] on Supine or prone percutaneous nephrolithotomy: do anatomical changes make it worse. Study done by Brian et al[11] included 20 patients. Study done by Wang et al[12] consisted of 122 patients in comparing the efficacy and safety of percutaneous nephrolithotomy (PCNL) in the prone and modified supine positions

Mean age was 48.98 years with a standard deviation of 14.14 years in our study. The minimum age was 22 years and maximum age was 80 years. In the study done by Wang et al[12] the age group of 22-70 years was included. Study done by Brian et al[11] range of age was from 48.6–86.4 years (mean age is 68.2 years). A study done by Karim et al[13] median age of the male patients was 47 years and in female it was 41 years.

In our study, 28(56%) were females and 22(44%) were males. A study done by jones et al[14]had 56% of males and 44 % of females in their study. Study done by Wang et al[12] had 51% of males and 49 % of females in comparing the efficacy and safety of percutaneous-nephrolithotomy (PCNL) in the prone and modified supine positions. A study done by Brian et al15 had 80% of males and 20% of females.

In nephrostomy tract length this study shows that there was a reduction in nephrostomy tract length in prone position which was statistically significant (p <0.001). on conclusion there was shorter tract length in prone position compared to supine and supine oblique position.

Study published by Brian et al [11] showed that the mean nephrostomy tract length was less in the prone position (82.6 mm right kidney, 85.4 mm left kidney) compared with the supine position (108.3 mm right kidney, P

<.001; 103.7 mm left kidney, P <.001). Prone tract length was also less than supine oblique tract length (86.1 mm vs 96.5 mm; P = .048).

Yazici et al[(10)] showed that the mean nephrostomy tract lengths and the subcutaneous fat tissue lengths in the lower, middle, and upper poles of kidney were significantly more in the supine position.

Raed A Azhar et al [(15)] did a study on visceral organ to tract distance in prone and supine positions. Study showed that visceral organ to tract distance was significantly shorter in the prone position when compared with the supine position (2.8 cm vs 3.5 cm, P=0.04).

In the case of maximum access angle, we found that there was an increase in maximum access angle in the prone position, which was statistically significant (*p* -0.024-right and p value -0.001-left). In conclusion, there was a wide access angle in the prone position when compared to the supine and supine oblique positions.

Study supported by Brian et al[(11)] which showed that mean maximum access angle was significantly greater (P = .018 right kidney; P = .007 left kidney) in the prone position (right kidney 99.7°, left kidney 104.0°) compared with the supine position (right kidney 87.7°, left kidney 89.4°). The Mean maximum access angle was significantly greater in the prone compared with the supine oblique position.

Yazici et al[(10)] showed the access field was shorter in supine than prone and prone-flexed position.

Raed A Azhar et al[(15)] did a study on visceral organ to tract distance in prone and supine positions. Study showed that the prone position showed significant association with wider angles when compared to supine position, which is similar to our study.

In renal pelvis ap diameter the mean renal pelvis AP diameter differed statistically significantly between supine, prone and oblique positions. Prone position earned increase in renal pelvis AP diameter which was statistically significant (p -0.01- right and p -0.03- left).

Duty et al [(11)] showed that there was no difference in antero-posterior renal position between the supine and prone positions or supine oblique and prone positions. They concluded that the prone position is associated with a significantly shorter nephrostomy tract length and more potential access sites, which may improve ease and safety of percutaneous renal access, but no difference in AP renal position.

Roshan M Patel et al [(16)] did a review on the latest developments related to positioning in the practice of PCNL. They concluded from a meta-analysis that superior stone-free rate in the prone position and comparable complication rates to the supine position.

Birowo et al[(17)] did a study to compare the efficacy and safety profile of the supine and prone position when performing PCNL using met-analysis among 11 articles. The stone free rate is higher in prone position compared to supine position.

Abdul Fatah Ahmed et al[(18)] concluded that the Stone Free Rate was higher in prone position (77.8%) and 75.4% in split-leg (SL) modified lateral position (MLP)-SL-MLP group.

LIMITATIONS:

As percutaneous nephrostomy procedure was not done in all the patients, further more studies are required with percutaneous nephrostomy procedure, in order to find the ideal position for PCN. As the number of subjects where less generalizability of the study was reduced.

CONCLUSION:

The study concluded that there was difference in anatomical parameters between prone, supine and supine oblique positions. Nephrostomy tract length was less, Maximum access angle and Renal Pelvis antero-posterior (AP) Diameter was more in prone position compared to supine and supine oblique positions. This was statistically significant. Since there was less nephrostomy tract length, more Maximum access angle and Renal Pelvis AP Diameter in Prone position, prone position is ideal for easy surgical manipulations in kidney when compared to supine and supine oblique positions.

DECLARATIONS

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Conflict of interest: None declared

Ethical approval: Ethical approval obtained from Institutional Ethical Committee-1489/IEC/2018

REFERENCES:

1. Soriano RM, Penfold D, Leslie SW. Anatomy, Abdomen and Pelvis, Kidneys. In: StatPearls. Treasure Island (FL): StatPearls Publishing.p.678-690
2. Bowdino CS, Shaw PM. Anatomy, Abdomen and Pelvis, Renal Veins. In: StatPearls. Treasure Island (FL): StatPearls Publishing.p.456-478
3. Lescay HA, Tuma F. Anatomy, Abdomen and Pelvis, Ureter. In: StatPearls. Treasure island (FL): StatPearlsPublishing;p.567-580.
4. Coccolini, F., Catena, F., Kluger, Y., Sartelli, M., Baiocchi, G., Ansaloni, L., & Moore, E. E. (2018). Abdominopelvic trauma: from anatomical to anatomo-physiological classification. *World Journal of Emergency Surgery*, *13*(1). https://doi.org/10.1186/s13017-018-0211-4
5. Lung K, Lui F. Anatomy, Abdomen and Pelvis, Arteries. In: StatPearls. Treasure Island (FL): StatPearls Publishing; 2020p.67-78.
6. Macchi, V., Picardi, E., Inferrera, A., Porzionato, A., Crestani, A., Novara, G., De Caro, R., & Ficarra, V. (2018). Anatomic and Radiologic Study of Renal Avascular Plane (Brödel's Line) and Its Potential Relevance on Percutaneous and Surgical Approaches to the Kidney. Journal of endourology, 32(2), 154–159. https://doi.org/10.1089/end.2017.0689.
7. Jairath, A., Ganpule, A., & Desai, M. (2017). Percutaneous nephrostomy step by step. Mini-Invasive Surgery. https://doi.org/10.20517/2574-1225.2017.24
8. Dagli, M., & Ramchandani, P. (2011). Percutaneous nephrostomy: technical aspects and indications. Seminars in interventional radiology, 28(4), 424–437.

https://doi.org/10.1055/s-0031-1296085.

9. Young M, Leslie SW. Percutaneous Nephrostomy. In: StatPearls . (FL): StatPearls Publishing.p.33-39.
10. Yazici, C. M., Kayhan, A., & Dogan, C. (2014). Supine or prone percutaneous nephrolithotomy: Do anatomical changes make it worse? *Journal of Endourology*, *28*(1), 10–16. https://doi.org/10.1089/end.2013.0541.
11. Duty, B., Waingankar, N., Okhunov, Z., Ben Levi, E., Smith, A., & Okeke, Z. (2012). Anatomical variation between the prone, supine, and supine oblique positions on computed tomography: Implications for percutaneous nephrolithotomy access. *Urology*, *79*(1), 67–71. https://doi.org/10.1016/j.urology.2011.06.019.
12. Wang, Y., Wang, Y., Yao, Y., Xu, N., Zhang, H., Chen, Q., Lu, Z., Hu, J., Wang, X., Lu, J., Hao, Y., Jiang, F., Hou, Y., & Wang, C. (2013). Prone versus modified supine position in percutaneous nephrolithotomy: A prospective randomized study. *International Journal of Medical Sciences*, *10*(11), 1518–1523. https://doi.org/10.7150/ijms.6305.
13. Aich, R., Das, U., Deb, P., Karim, R., Sengupta, S., & Samanta, S. (2010). Percutaneous nephrostomy by direct puncture technique: An observational study. *Indian Journal of Nephrology*, *20*(2), 84. https://doi.org/10.4103/0971-4065.65301.
14. Jones, M. N., Ranasinghe, W., Cetti, R., Newell, B., Chu, K., Harper, M., Kourambas, J., &McCahy, P. (2016). Modified supine versus prone percutaneous nephrolithotomy: Surgical outcomes from a tertiary teaching hospital. Investigative and clinical urology, 57(4), 268–273. https://doi.org/10.4111/icu.2016.57.4.268.
15. Azhar, R. A., Szymanski, K. M., Lemercier, E., Valenti, D., Andonian, S., &Anidjar, M. (2011). Visceral organ-to-percutaneous tract distance is shorter when patients are placed in the prone position on bolsters compared with the supine position. Journal of endourology, 25(4), 687–690. https://doi.org/10.1089/end.2010.0547.
16. Patel, R. M., Okhunov, Z., Clayman, R. V., & Landman, J. (2017). Prone Versus Supine Percutaneous Nephrolithotomy: What Is Your Position?. Current urology reports, 18(4), 26. https://doi.org/10.1007/s11934-017-0676-9.
17. Birowo P, Tendi W, Widyahening IS et al. Supine versus prone position in percutaneous nephrolithotomy: a systematic review and meta-analysis F1000Research 2020, 9:23.
18. Ahmed A, Gomaa A, Daoud A, Solyman A, Abdelazim H, El-feky M, et al. Split-leg modified lateral versus prone position in percutaneous nephrolithotomy: a prospective, randomized trial. World Journal of Urology 2020 Jun 2

Legends:

Figure 1(a): Right Renal Supine Nephrostomy Tract Length
Figure 1(b): Right Renal Supine Maximum Access Angle

Figure 1(c): Right Renal Supine Pelvis AP Diameter

Figure 2a: ESTIMATED MARGINAL MEANS OFMEASURE-RIGHT NEPHROSTOMY TRACT LENGTH

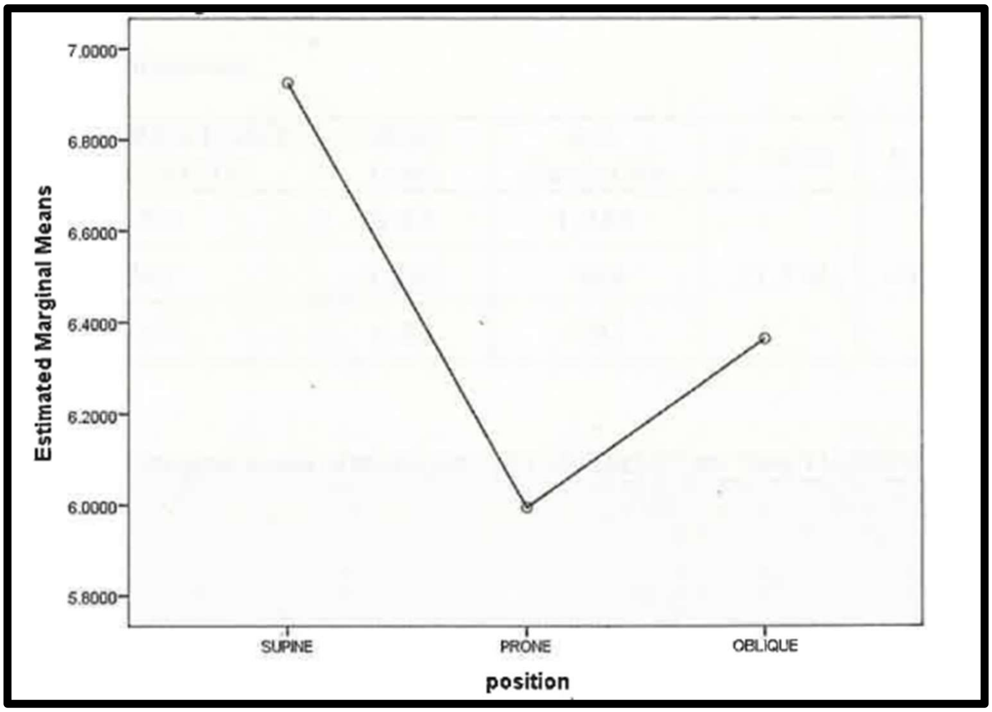

Figure 2b: ESTIMATED MARGINAL MEANS OFMEASURE-LEFT NEPHROSTOMY TRACT LENGTH

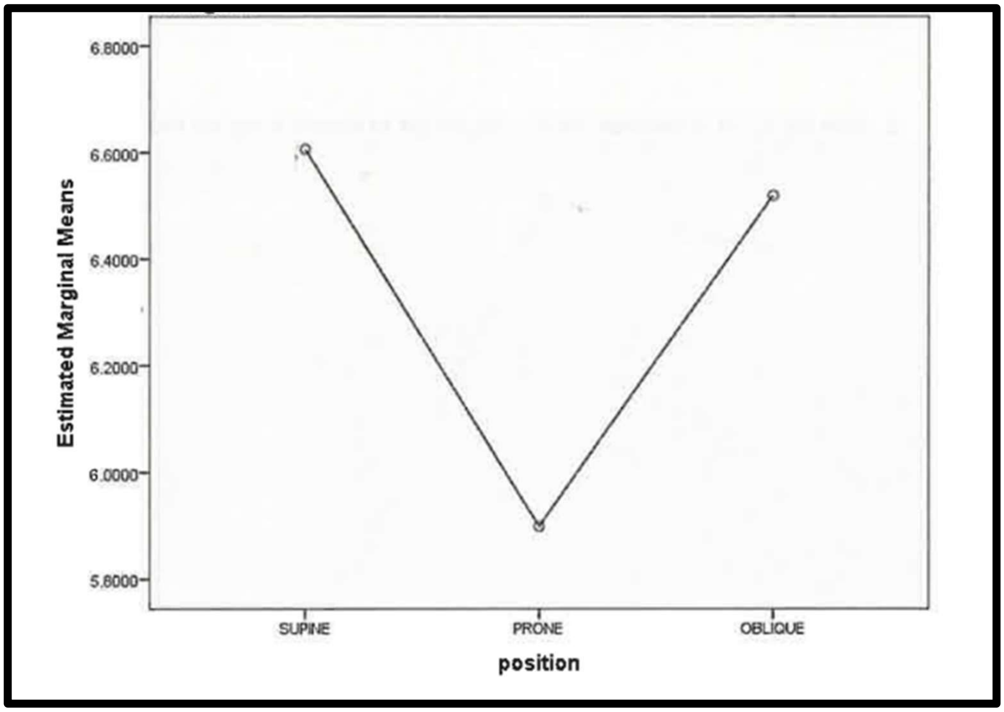

Figure 3a: ESTIMATED MARGINAL MEANS OFMEASURE- LEFT MAXIMUM ACCESS LENGTH

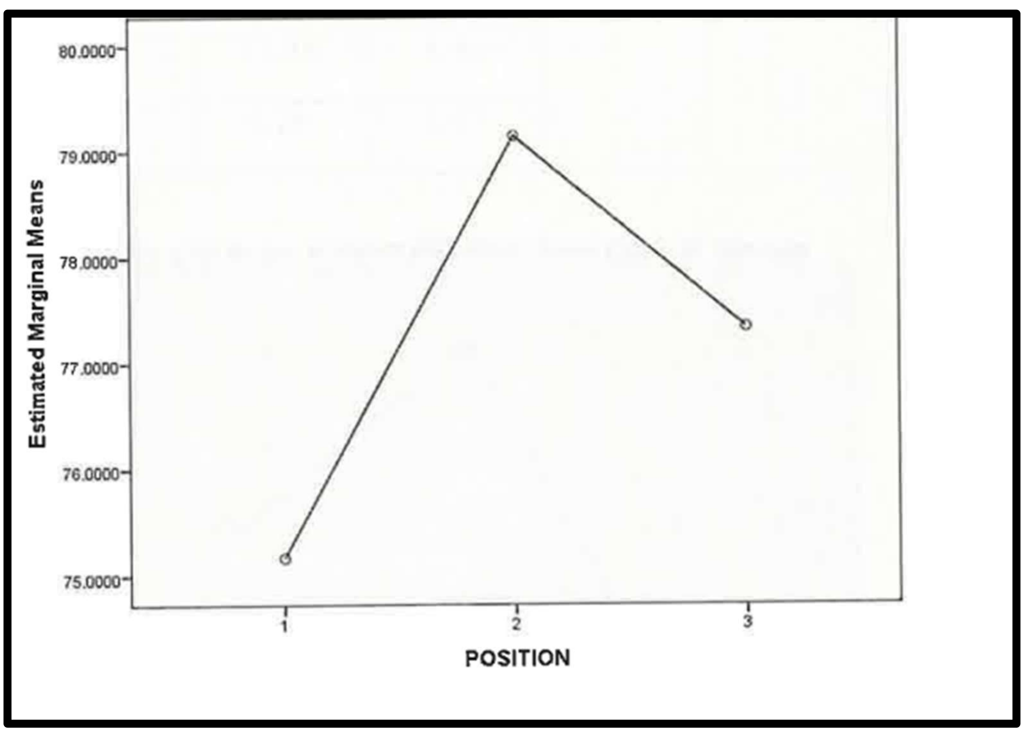

Figure 3b: ESTIMATED MARGINAL MEANS OFMEASURE-RIGHT MAXIMUM ACCESS LENGTH

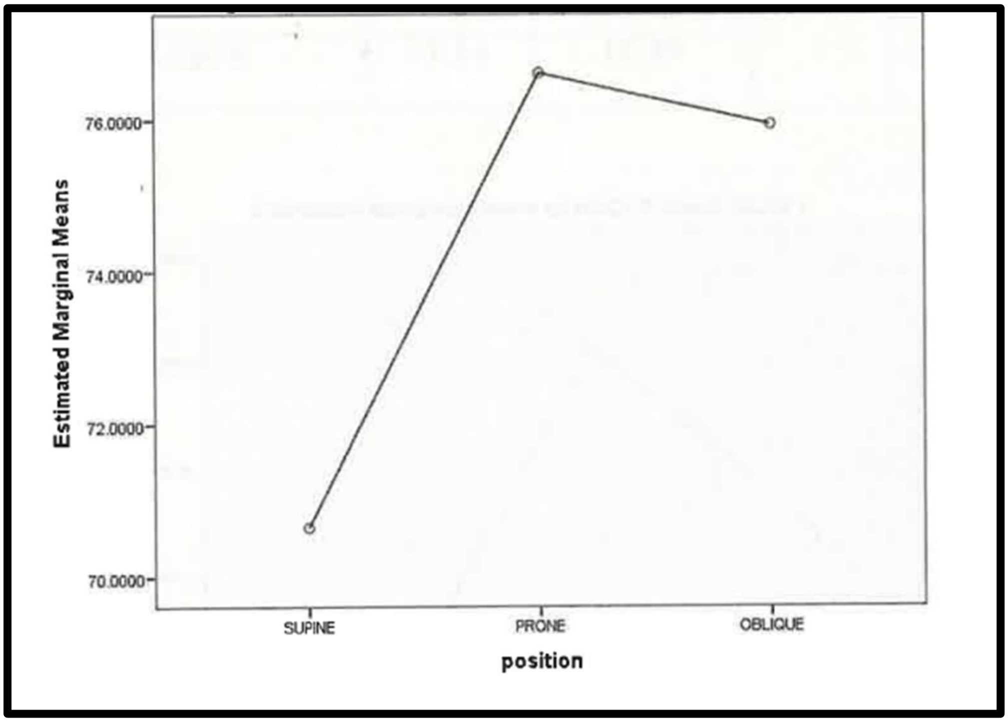

Figure 4a: ESTIMATED MARGINAL MEANS OFMEASURE- LEFT RENAL PELVIS AP DIAMETER

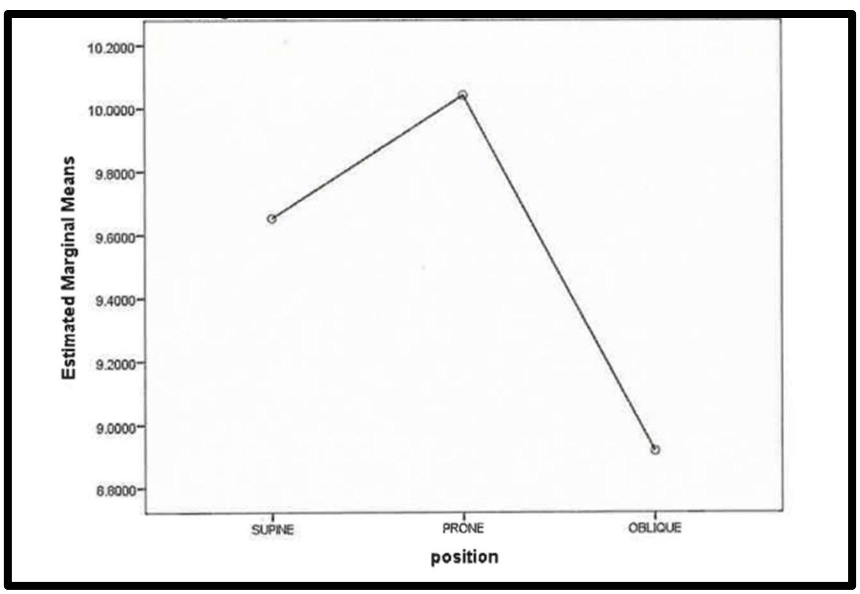

Figure 4b: ESTIMATED MARGINAL MEANS OFMEASURE- LEFT RENAL PELVIS AP DIAMETER