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A Study to Determine the Ideal Mesh Size and the Incidence of Low Lying Pubic Tubercle in Inguinal Hernia

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Abstract

Aims And Objectives: In-vivo inguinal measurements to estimate the optimal mesh size for inguinal hernioplasty and to establish the relationship between low lying pubic tubercle and the development of inguinal hernia

Methods: This was an observational study conducted from July 2018 to September 2020. 58 patients were purposively sampled. In order to determine the optimal mesh size according to the original recommended surgical technique. In-vivo measurements of key dimensions of the inguinal floor were taken in patients undergoing herniorrhaphy.Spino-Spinal (SS) and Spino-Tubercular (ST) measurements were also taken and compared with a control population.

Results: Measurements were taken in 58 patients: 56 men and 2 women, mean age 43 years (SD 13.6); 42 with indirect hernias, 16 with direct. Allowing for recommended mesh overlaps, the optimal mesh size for provision to be appropriate for the majority of patients was determined to be 9.0 cm x 13.0 cm, 29% wider than the mesh size currently recommended for use in Lichtenstein hernioplasty. The incidence of hernia was noted to be more on the right side. The mean value of ST line in our study group is 6.04±0.28 cm which is significantly greater than the controls with the mean value being 5.73±0.19 cm. It was also found that BMI had a significant influence on the incidence of inguinal hernia.

Conclusions: An appropriate size for routine provision in low resource settings, or other settings where the provision of several mesh sizes is not supportable, may be 9.0 cm x 13.0 cm. People with low lying pubic tubercle and higher BMI are at a higher risk of developing inguinal hernia

Keywords: Hernia, mesh, pubic tubercle, inguinal.

INTRODUCTION

Inguinal hernias account for 75% of abdominal wall hernias. Lifetime risk of 27% in men and 3% in women. Hernioplasty is one of the most common operations done in general surgery. Numerous repair techniques were described since Eduardo Bassini published his first repair in 1890. The Lichtenstein hernioplasty technique is widely used and is the gold standard surgery for hernia repair that uses prosthetic mesh to reinforce the area of weakness.

In-spite of following recommendations of Lichenstein's repair, hernia recurrences are noted as high as 30% .Hence a need to re-evaluate the mesh size in itself arises since multiple other materials and techniques are already in place.

In case of low lying pubic tubercle, the structural anatomy is altered and the obliquity of the inguinal canal gets decreased, arching of conjoint tendon gets narrowed. The shutter mechanism of internal obliqus gets diminished leading to the ineffective defense

mechanism ending up in the development of inguinal hernia. [1]

AIMS

1. In-vivo inguinal measurements to estimate the optimal mesh size for inguinal hernioplasty
2. To establish the relationship between low lying pubic tubercle and the development of inguinal hernia

MATERIALS AND METHODS

Source of data: In patient admitted to the Department of General Surgery, KIMS Hospital, Bangalore.

Methods Of Collection Of Data:

1. Study design: Prospective, hospital based Observational study
2. Study period: From July2018 to September 2020
3. Place of study: KIMS Hospital, BANGALORE
4. Sample size: 58
5. Inclusion Criteria :
    a. All patients admitted and posted for elective inguinal hernioplasty using the Lichtenstein technique for direct or indirect inguinal hernia at the Department of Surgery in KIMS Hospital, Bangalore
    b. Reducible uncomplicated inguinal hernia
    c. Age above 18years.

Exclusion Criteria:

1. Complicated inguinal hernia(strangulation, obstruction , etc)
2. Children below the age of 18 yrs.
3. Recurrent inguinal hernia

Methodology:

1. After having obtained approval and clearance from the institutional ethics committee, the patients fulfilling the inclusion criteria were enrolled for the study after obtaining informed consent.
2. The prospective study was done on patients who were admitted in Surgery ward with inguinal hernia.
3. 58 patients with inguinal hernia. Complete history, physical examination and investigations were taken after determining the sample size. The patients were positioned in a supine relaxed position on hard bed.
4. All measurements were taken in person by a single investigator, hence adding more credibility to the values.
5. A line was drawn on the anterior abdominal wall, connecting both anterior superior iliac spine which was given the name ‘SS Line’.
6. Next the pubic tubercle on the side of hernia was marked by the palpation. Then vertical distance between this point and the SS Line was measured. This line was designated as ST line.
7. Intra-operatively, after the opening of the external oblique aponeurosis, the landmark structures were identified and measurements were taken using a sterile ruler.
8. Points of measurement include: Figure 1 (a, b)
    a) Maximum diameter of the internal inguinal ring. – ‘A’
    b) Length of the inguinal ligament from the pubic tubercle up to the inferior border of the internal inguinal ring. – ‘B’
    c) Length of the transverse arch aponeurosis from the pubic tubercle up to a point at the level of the inferior border of the internal inguinal ring.- ‘C’
    d) The distance between the midpoint of the inguinal ligament(measured from the pubic tubercle to the internal inguinal ring) and the transverse arch aponeurosis – ‘D’

Figure 2 showing Intra-operative measurements being taken

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The study subjects were asked to lie in supine relaxed position on hard bed. Keeping both their lower limbs straight, so that both the anterior superior iliac spine are at the same level. A line is drawn on the anterior abdominal wall. Connecting both anterior superior iliac spine which is given the name SS Line and the length of SS Line is noted; next the pubic tubercle on the side of hernia is marked by the palpation. Then vertical distance between this point and the SS Line is measured in centimeters. This line is designated as ST line. Similar measurement was done on controls as well.

Assessment tools: two flexible stainless steel sterilized measuring rulers.

OBSERVATION AND RESULTS

This prospective observational study included 58 consecutively purposively sampled patients after ruling out patients not suiting the inclusion criteria. These patients were labeled as 'Cases' and 58 other patients were randomly picked up from the wards admitted for various other ailments, for the study after taking consent and were labeled as 'Controls'.

Table 1, shows the gender distribution among the patients taken up in the study as cases and controls

As noted here, majority of the patients are males (96.6% - cases)[(3)(4)] , in accordance with studies such as Burcharth et al and Ramji et al which also found an overwhelming predominance of inguinal hernia in the male gender and similarly the control was accordingly matched. (Chart 1)

Table 2, divides the cases and controls into age groups of 10. Majority of the patients showing a bimodal presentation falling in the 3rd and 6th decade of life (Chart 2)

Further it was noted that majority of the patients in the study had right sided inguinal hernia(46.6%) followed by left side of 34.5% as shown in Table 3

Chart 3 indicates that Measurement A (Representing the diameter of the internal ring) in a majority of the patients were found to be within 1.5cm.

Measurement B (Representing the in-vivo inguinal canal measurement) was found to be >4.5 cm in majority of the inguinal hernia cases as opposed to the normal length of approx. 4cm. This indicates an elongation of the inguinal canal in case of inguinal hernia.

Measurement C and D indicate the area that a mesh covers over the defect.

Table 5: Shows In-vivo inguinal measurements: DESCRIPTIVE STATISTICS

95% CI computed as reference Interval method.

Chart 4 shows In-vivo inguinal measurements: DESCRIPTIVE ANALYSIS

These measurements suggest that the mean size of the inguinal floor that requires mesh support in the Lichtenstein technique is 4.0 x 4.53 cm.

Studies have shown that it is normal for a mesh to shrink up to 4 to 7% in 3 months and as much as 20% in 10 months after implant, although the degree of shrinkage can vary between mesh types [(19)].To allow for shrinkage and reduce recurrence of hernia, it has been recommended that overlaps be allowed on the points of fixation of the mesh of 3.0 to 4.0 cm beyond the transverse arch aponeurosis, 2.0 cm beyond the pubic tubercle, and 5.0 to 6.0 cm lateral to the internal inguinal ring. Adding 4.0 cm to allow for these overlaps to the mean of 'D' gives a mesh width ('D' + 4.0 cm). Adding 8.0 cm (6 cm + 2 cm) to the length of the transverse arch aponeurosis ('C') gives a mesh length ('C' + 8.0 cm). Taking into consideration the upper limit of the recommended overlaps to reduce the chances of recurrences, we the upper limit of C and D into consideration. Thus the inguinal mesh size arrived at would be ('5.14' + 4) x ('5.7' +8), which amounts to approximately 9 x13 cm according to this study.

Table 6 shows Comparison of height, weight and BMI according to case and controls studied : indicating a significant anthropometric variation in the population with and without hernia.

Chart 5 shows BMI distribution

Table 7 shows Descriptive statistics –baseline variables

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Table 8 shows Descriptive statistics –Inguinal Measurement

Chart 6 shows Descriptive statistics –Inguinal Measurement

Table 9, 10, 11 shows the Pearson correlation for height, weight and BMI

Descriptive analysis and Correlation shows a significant correlation between ST Measurement on the right side to weight and BMI

DISCUSSION

The anatomy of the inguinal region and the anatomy of the pelvis by extension has always proved to be a major factor in the development of inguinal hernia. The muscles, ligaments and tendons and their various attachments provide defence mechanisms that prevent hernia formation. The lateral abdominal wall muscles which include the transversus abdominis and the internal oblique muscle, form the conjoint tendon and offer reinforcement only in the medial half of the inguinal canal as it arches over the deep ring which makes it the weakest part of the posterior wall. A low lying pubic tubercle is associated with a narrow origin of the internal oblique muscle which further weakens the posterior wall at the deep ring, which in turn increases the risk of development of indirect inguinal hernia.

Inguinal hernia is much more common in men as compared to women as mentioned earlier and in comparison to other studies done before[(2)]. The age-distributed prevalence rates shows that inguinal hernia prevalence was peaking at adult age group showed a bimodal presentation between the 3rd and 6th decade in this study, whereas Bansal and Anil et al study showed that the peak incidence of inguinal hernia was 42 to 57 years [(3)]. It is relatively less common in adolescent age groups. Some studies have shown that age distribution is bimodal peaking at early childhood and old age. This can be explained on the basis that most patients especially of the lower socioeconomic group do not present to the hospital during the initial presentation of the disease, instead opting for surgery only when the disease becomes a hindrance to their occupation or day to day activities.[(4)]

The change in evolutionary change in posture to upright from prone has reduced the efficiency of the shutter mechanism of inguinal canal which is protective against formation of inguinal hernia. The erect posture of man and the horizontal course of the muscle fibres have predisposed the inguinal region to weakness. The conjoint tendon has a variable distance from the inguinal ligament, causing a defect in the Fruchaud's area. [(2)]

Lopez- Cano et al (2005) study showed that the low pubic arch population of people showed a significantly longer inguinal ligament and a greater angle made by the superior border of the supra-inguinal space and inguinal ligament at its medial insertion.[(5)]

The lowness of the pubic tubercle has direct repercussions leading to morphological alterations are found in the external oblique, internal oblique, transversus, cremastric muscles and the fascia transversalis. The shutter-like mechanism at the internal inguinal ring is provided by contraction of the arching fibers of the internal oblique muscle, shorten and approximate themselves over the inguinal ligament and prevent sliding of the spermatic cord. An abberant origin and insertion of internal oblique and transverses abdominis muscle results in an ineffective shutter mechanism . The low pubic tubercle group showed a significantly higher incidence of right sided inguinal hernia which inturm showed a significantly longer inguinal canal and longer inguinal ligament . [(6)]

Radojevic calculated the angle created between the interspinal line and Malgaigne's line and concluded that a large angle increases the risk of development of inguinal hernia. Radojevic and Ami independently studied the pubic height. Both arrived at the same conclusion that greater the pubic height, more likely are the chances of developing hernia due to a larger Fruchaud's area, a theory postulated by a French Professor named Georges Chavannaz [(7)]

The greater length of inguinal ligament and a larger supra-inguinal angle may account for a greater area of supra-inguinal space which may account for a deficient function of the shutter mechanism. Harris and White et al showed that a greater length of the inguinal ligament had a higher tendency to develop inguinal hernia[(8)]. Ajmani and Ajmani (1983)et al, a study of the basis of inguinal hernia, a study on cadavers noticed that in the inguinal hernia patients,

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the origin of internal oblique from the inguinal ligament was away from the pubic tubercle and its lower fibres did not approximate properly over the deep ring, leaving it unprotected and hence allowing the hernial sac to push through when the intra-abdominal pressure is increased. Also , in the study group it was noticed that the inguinal canal in patients with low lying pubic tubercle being more longer was more oblique and hence the hernia sac could slip out easily through the canal due to gravitational pull than when the canal is more horizontal in the control group.[9]

The unusual origin and insertion of internal oblique and transverses abdominis muscle, results in an ineffective shutter mechanism of the inguinal canal. Agrawat M et al undertook a study of 135 cases of inguinal and came to similar conclusions [10]

So we can state that the functional significance of the inguinal region is modified by bony, ligament and muscular variations and hence, knowledge of the structural characteristics, helps the surgeon to perform the surgical technique appropriately, irrespective of the approach. This anthropometric study of pelvis will enable the surgeons to categorize people with low lying pubic tubercle as prone for hernia development and hence advice lifestyle modifications accordingly in their daily activities. In case of patients who have already developed inguinal hernia with low lying pubic tubercle can be planned to undergo herniorraphy for the posterior wall along with reinforcement for the deep ring by mesh(hernioplasty) since they have unprotected deep ring and weak shutter mechanism. The identification of structural characteristics of the inguinal region eases the selection of the most appropriate operation procedure, hernioplasty. In patients with low-lying pubic tubercle, the gap between inguinal ligament and the lower border of musculo-aponeurotic arch is greater. All patients in our study underwent conventional hernioplasty and no recurrence noted in the follow up till date Of the multiple techniques for hernia repair, the Lichtenstein tension-free hernioplasty is the most widely used technique and more or less considered the gold standard in open inguinal repairs by the American College of Surgeons and to have low recurrence rates and less postoperative pain . The principle behind using a mesh was that it reinforces the abdominal wall with the formation of scar tissue. The recent Asian guidelines on inguinal hernia repair recommend that, depending on size of defect, the mesh should allow for a large coverage and overlap the pubic bone by at least 1 to 2 cm medially and overlap the surrounding area by more than 3 cm in all directions. It is recommended that a minimum of 8 × 12 cm mesh be used for anterior repair . Lichtenstein first described the use of a 3 cm × 8 cm mesh for direct and indirect inguinal hernioplasty. However, long-term follow-up results showed that this size of the mesh might not be sufficient to prevent recurrence; afterward, the institute recommended to increase the size of the mesh to 7 cm × 15 cm .Research by Amid P.K et al has suggested that provision of adequate overlaps can help to reduce recurrence rates by compensating for the mesh shrinkage that has been observed in experimental studies [11].The recommended 15.0-cm mesh length intends to provide ease of manipulation, with up to 3.0–4.0 cm being trimmed when it is in place. However, the basis for the 7.0 × 15.0 cm size is not known. Currently, there is a lack of published studies based on actual measurement of the inguinal floor which needs support.

Proper mesh size is important in preventing recurrence. Intra-operative observations in recurrent hernia cases have revealed that the mesh slipped away from its medial fixation .[12] This happens more commonly where a mesh is too large or too small: a large mesh can wrinkle, slipping from where it is anchored; shrinkage of a mesh that is too small can result in its being released from its points of fixation due to tension .[13]

A wide variety of meshes are manufactured in different styles and sizes. The availability of a range of products may be advantageous. However, in developing countries, a manufacturer must identify an affordable single product or limited range of products for use for all cases. In terms of mesh length, the size determined by this study is 13% shorter than the 15.0 cm mesh recommended for use in the Lichtenstein technique. However, the 9 cm mesh width determined by this study is 29% wider than the recommended 7.0 cm. That the recommended mesh size may be too narrow in a proportion of the patient population is worrying as this has potential clinical implications: where the mesh is too narrow, in these patients it will not be

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possible to provide the size of overlap that is recommended to prevent recurrence. These calculations have used the higher of the 95% confidence intervals to offer some degree of certainty that the true mean has been taken into account. Consideration of the full range of observed measurements further highlights that while the recommended length is appropriate, the recommended mesh width is a cause for concern in some cases.

A prospective trial would be needed to determine what patient benefit, if any, would result from the adoption of 8.5cm x 14cm as the standard flat mesh size. The findings of this study may be of interest to manufacturers in determining the standard size of meshes they produce and to those who make surgical supply purchasing decisions. This study is rare in its use of direct in vivo measurements of the inguinal floor to determine an optimal dimension for mesh implants. Another advantage in the study is that since all the measurements were taken by a single investigator, the chances of errors were minimised.

The study also has limitations that must be acknowledged. It is a small sample, but the confidence intervals generated are relatively narrow, indicating consistency in measurements. The population considered is South India, whether there may be regional variations in anatomical measurements that should be considered. Only a small proportion of patients included had direct inguinal hernias. Further studies in larger samples of different ethnic origin are recommended, as are studies in patients with direct and indirect inguinal hernia in order to determine whether different optimal mesh sizes exist for the two indications.

Similar studies were conducted by Anitha B et al , Abhishek et al and Rabe et al which concluded on a mesh size of 9 x 15 , 6.7 x 13.8 and 8.5 x 14 respectively. The study done in our institute yielded similar results with both the studies agreeing to the fact that there is need for re-evaluation of the size of the mesh and its implications in the recurrences of hernia, after surgery.[14,15,16]

CONCLUSIONS

Configuration of bony pelvis seems to be a major contributing factor in determining the risk of development of inguinal hernia as evidenced by the variations in ST length. Other parameters such as Weight/ST and BMI/ST also showed statistically significant variations. Early identification of said risk factors in early adulthood could help in the prevention of hernia. Pelvimetry with radiograph correlation is a simple, and non-invasive method that could help in identification of the risk factors as well as adequately plan pre operatively the kind of hernia repair to be undertaken for individual patients.

It appears that the recommended size of mesh for use in inguinal herniorrhaphy may often be too narrow, potentially undermining the surgery's effectiveness and increasing the risk of recurrence. The implications of this finding are of particular importance in low-resource settings, where the provision of a range of mesh types and sizes may not be possible. The direct in vivo measurements reported by this study suggest that the provision of standard flat mesh implants of 9 x 13.0 cm would be appropriate for use in the majority of inguinal herniorrhaphy cases.

TABLES

Gender	Cases	Controls	Total
Female	2(3.4%)	4(6.9%)	6(5.2%)
Male	56(96.6%)	54(93.1%)	110(94.8%)
Total	58(100%)	58(100%)	116(100%)

Table 1: Gender distribution of patients studied P=0.679, Not significant, Fisher Exact test

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Age in years	Cases	Controls	Total
<20	2(3.4%)	1(1.7%)	3(2.6%)
20-30	13(22.4%)	0(0%)	13(11.2%)
31-40	8(13.8%)	9(15.5%)	17(14.7%)
41-50	8(13.8%)	10(17.2%)	18(15.5%)
51-60	7(12.1%)	26(44.8%)	33(28.4%)
61-70	16(27.6%)	8(13.8%)	24(20.7%)
>70	4(6.9%)	4(6.9%)	8(6.9%)
Total	58(100%)	58(100%)	116(100%)
Mean ± SD	48.45±18.49	54.47±12.35	51.46±15.94

P=0.042*, significant, Student t test

Table 2: Age distribution of patients studied

Diagnosis	No. of patients	%
Bilateral	10	18.9
Left	20	34.5
Right	27	46.6
Total	58	100.0

Table 3: Diagnosis distribution of patients studied

Variables	Cases	Controls	Total	P value
SS	27.40±1.45	27.10±1.13	27.25±1.30	0.225
ST Right	6.04±0.28	5.73±0.19	5.88±0.28	<0.001**
ST Left	5.82±1.14	5.73±0.18	5.78±0.82	0.579

Table 4: Comparison of SS/ST in cases and controls studied

Inguinal Measurements	Min	Max	Mean	SD	95%CI
A	1.00	2.80	1.45	0.28	0.90-1.99
B	3.70	6.20	5.13	0.47	4.19-6.05
C	3.20	5.60	4.53	0.60	3.36-5.70
D	2.50	4.90	4.00	0.58	2.85-5.14

Table 5: In-vivo inguinal measurements: DESCRIPTIVE STATISTICS

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Variables	Cases	Controls	Total	P value
Height (cm)	1.6305±6.81	1.64±0.05	81.64±8.120	<0.01*
Weight (kg)	61.63±8.86	66.10±8.75	63.89±9.05	0.007**
BMI (kg/m^2)	23.17±3.12	24.71±3.05	23.96±3.17	0.009**

Table 6: Comparison of height, weight and BMI according to case and controls studied: indicating a significant anthropometric variation in the population with and without hernia.

	Min	Max	Mean	SD
Age in years	17.00	85.00	48.45	18.49
SS	24.80	31.00	27.40	1.45
ST Right	5.20	6.70	6.04	0.28
STT Left	0.00	6.50	5.82	1.14
Height (cm)	145.00	180.00	163.05	6.81
Weight (kg)	43.00	83.00	61.63	8.86
BMI (kg/m^2)	17.21	31.23	23.17	3.12

Table 7 shows Descriptive statistics –baseline variables

Inguinal Measurements	Min	Max	Mean	SD
A	1.00	2.80	1.45	0.28
B	3.70	6.20	5.13	0.47
C	3.20	5.60	4.53	0.60
D	2.50	4.90	4.00	0.58

Table 8 shows Descriptive statistics –Inguinal Measurement

Variables	r value	P value
Height (cm) **vs** SS	0.143	0.294
Height (cm) **vs** ST Right	0.154	0.258
Height (cm) **vs** STT Left	-0.053	0.696
Height (cm) **vs** A	0.130	0.339

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Height (cm) **vs** B	-0.076	0.577
Height (cm) **vs** C	-0.149	0.274
Height (cm) **vs** D	-0.158	0.246

Table 9: Pearson correlation for height

Variables	r value	P value
Weight (kg) **vs** SS	0.200	0.139
Weight (kg) **vs** ST Right	0.323	0.015*
Weight (kg) **vs** STT Left	0.166	0.217
Weight (kg) **vs** A	0.175	0.198
Weight (kg) **vs** B	-0.086	0.527
Weight (kg) **vs** C	-0.030	0.827
Weight (kg) **vs** D	-0.130	0.339

Table 10: Pearson correlation for weight

Variables	r value	P value
BMI (kg/m^2) **vs** SS	0.114	0.408
BMI (kg/m^2) **vs** ST Right	0.255	0.060+
BMI (kg/m^2) **vs** STT Left	0.203	0.134
BMI (kg/m^2) **vs** A	0.121	0.379
BMI (kg/m^2) **vs** B	-0.019	0.888
BMI (kg/m^2) **vs** C	0.077	0.574
BMI (kg/m^2) **vs** D	-0.021	0.879

Table 11: Pearson correlation for BMI

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CHARTS

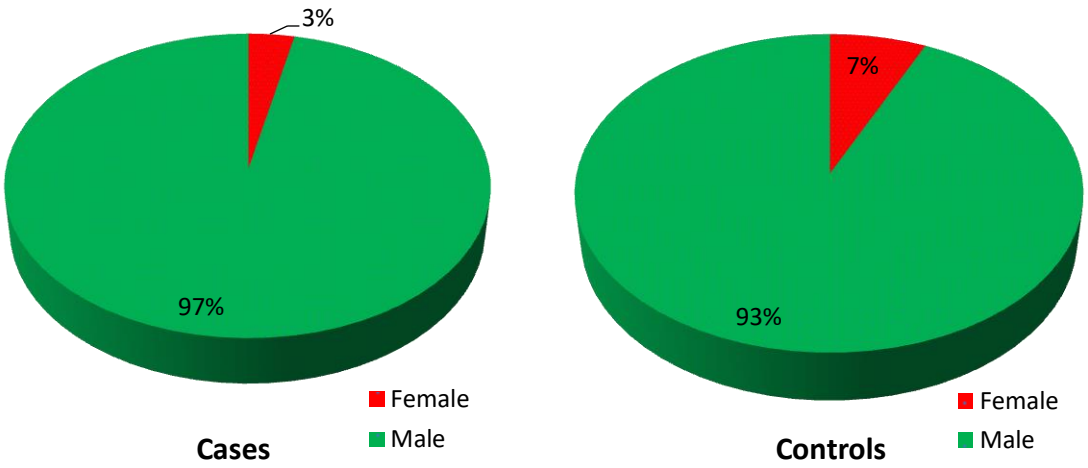


Chart 1: Gender distribution among cases and controls

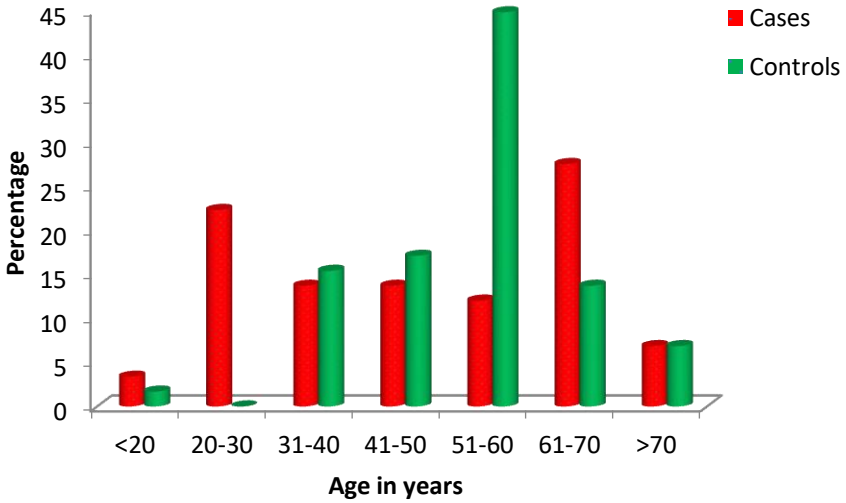
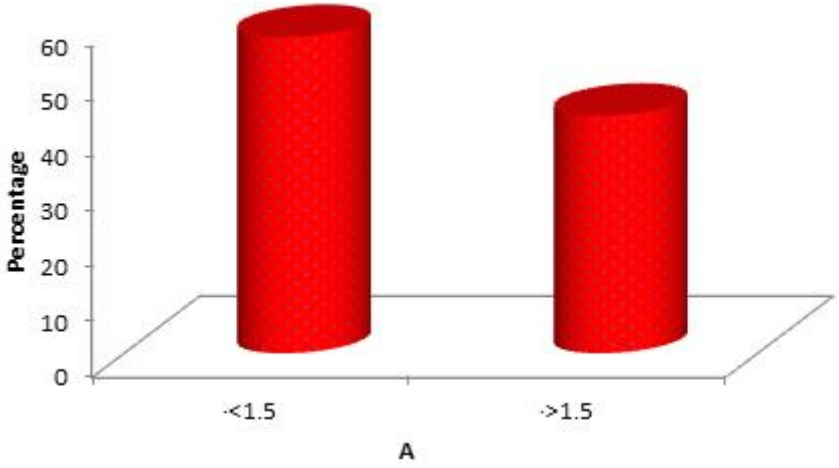


Chart 2: Age distribution of the cases and controls



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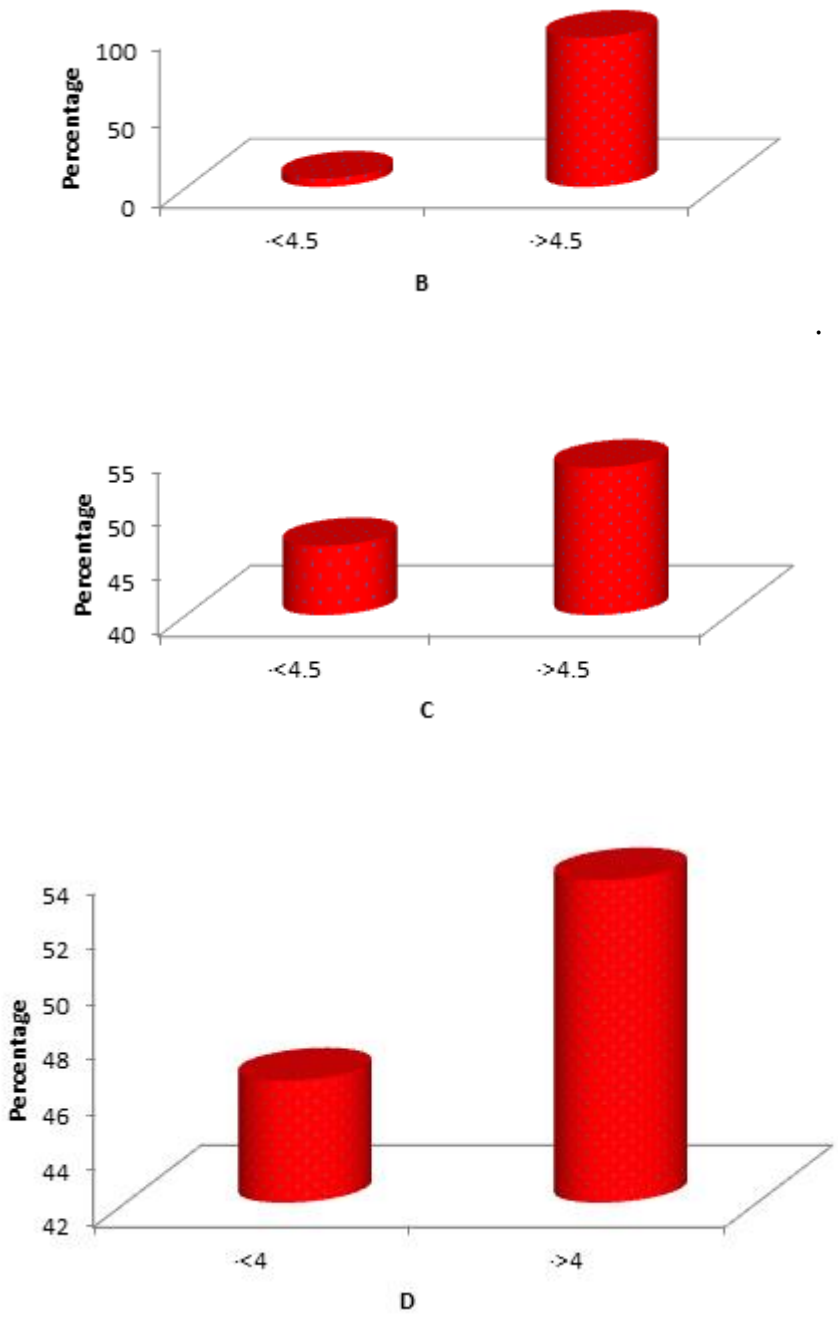

Chart 3(A, B, C, D): Measurements taken in-vivo in cases

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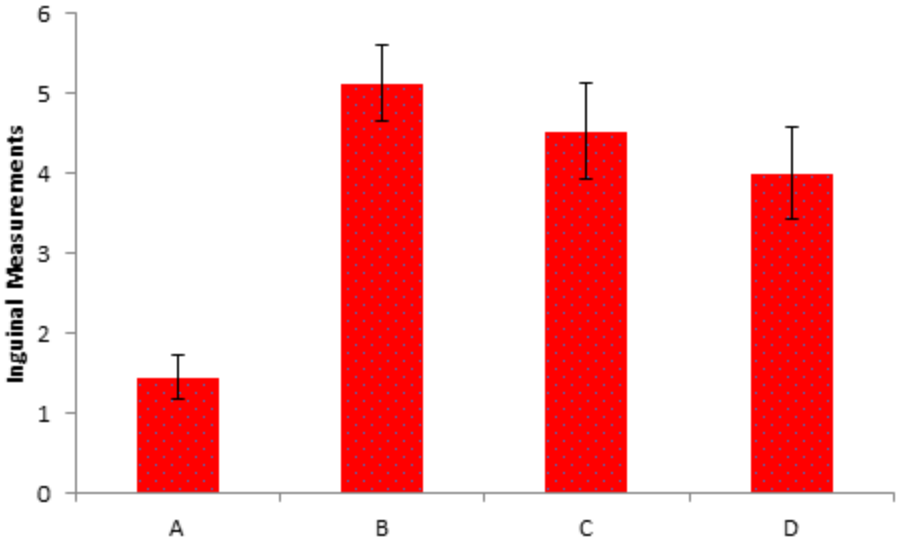

Chart 4 shows In-vivo inguinal measurements: DESCRIPTIVE ANALYSIS

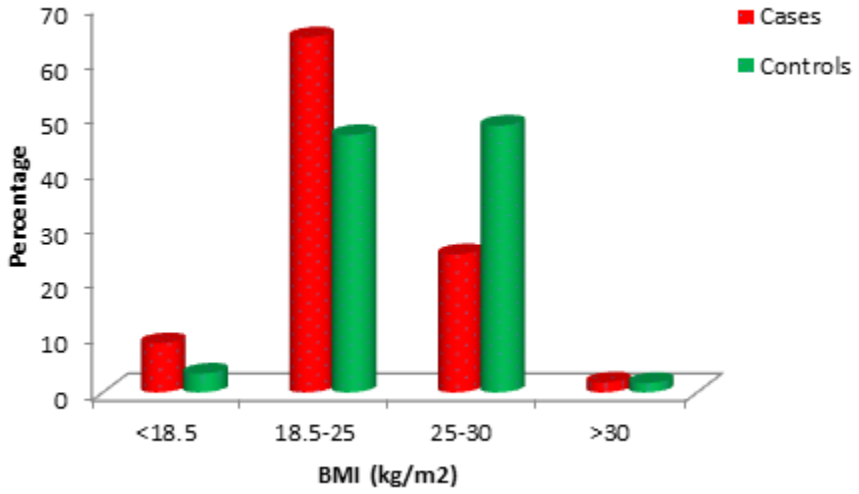

Chart 5 shows BMI distribution

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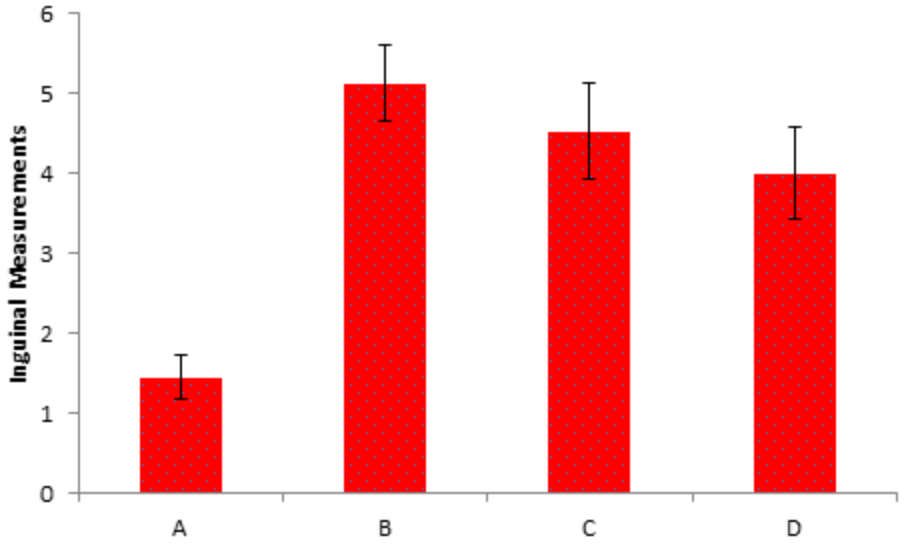

Chart 6 shows Descriptive statistics –Inguinal Measurement

FIGURES

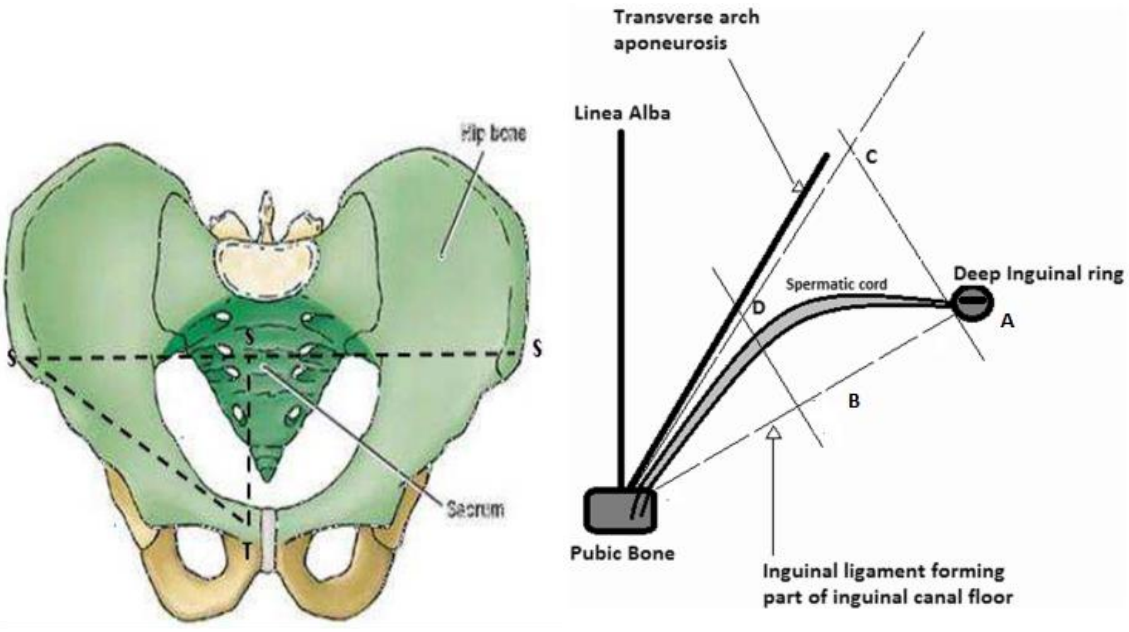

Figure 1 a) Bony measurements b) Intra-operative measurements

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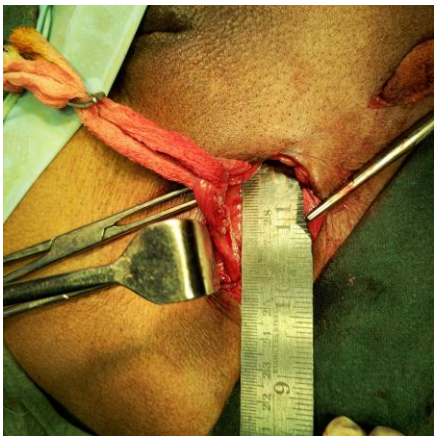

Figure 2 showing Intra-operative measurements being taken

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