Role of Anthropometric Data in Assessing Hamstring Graft Size in Anterior Cruciate Ligament Reconstruction

Sathesh Kumar Murthy[1], M. Sai Deiv Ramkumar[1],
Niranjan M. Raghavn[1*], B. Pooja[1] and Shanmuga Sundaram[1]

[1]*Department of Orthopedics, Saveetha Medical College and Hospital, Chennai, Tamil Nadu, India.*

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Original Research Article

ABSTRACT

Background and Objective: Preoperative information of hamstring graft size for anterior cruciate ligament reconstruction (ACL) is critical for making optimal graft selections. The aim of the present study was to view whether anthropometric parameters including height, weight, BMI and thigh circumference have any bearing on the size of hamstring tendon grafts used in anterior cruciate ligament replacement.

Methods: Pre-operative anthropometric measurements were taken on 72 patients undergoing primary ACL reconstruction, including age, gender, height, weight, BMI, and thigh circumference. The Person correlation coefficient was used to assess the correlation of these anthropometric variables and simple logistic regression was used to evaluate the correlation of these anthropometric variables on the size of the graft that was acquired.

Results: Gracilis tendon [GT] length correlates with height ($r^{1/4}$ 0,432), and semitendinosus [ST] length correlates with thigh circumference ($r^{1/4}$ 0,255). Women's graft diameter (7.16 ± 0.82 mm) smaller than that of men (7.39 ± 0.63 mm) (p > 0.05), although not statistically significant. The diameter of the autograft was shown to be strongly linked with parameters.

Conclusion: As a consequence, our findings suggest that anthropometric measures can be used in the preoperative planning and prediction of hamstring graft length and diameter in anterior cruciate ligament reconstruction.

1. INTRODUCTION

The knee is a complex joint, which allows for everyday activity like standing, walking, running, jumping and sitting. The anterior cruciate ligament (ACL) is a band of dense connective tissue which courses from the femur to the tibia. [1] The ACL is one of the major ligaments used in the stability of the knee. ACL injury is one of the most common knee injuries, and it most commonly occurs during sports such as football, which requires constant turning of the knee, as well as damage to the intraarticular structures. Functional disability is also caused due to trauma. The ligament is twenty two to thirty-eight millimetre in length and seven to ten millimetres in breadth. Ligaments are tough tissue bands that link one bone to another. The ACL links thighbone to shinbone and helps to maintain the knee joint. It is one of two ligaments that cross in the centre of knee. When a ligament is injured, it typically results in a partial or full tear of the tissue. A mild injury may stretch the ligament but leave it intact [2]. Thus, this ligament is necessary to sustain the normal movement of the knee. The major role of the ligament is to sustain ventral gliding of tibia over the femur and also maintain dorsal gliding of femur when the tibia is fixed [3].

The anterior cruciate ligament runs diagonally in the middle of the knee. It prevents the tibia from sliding out in front of the femur, as well as provides rotational stability to the knee. [4] The anterior cruciate ligament can be injured in several ways like Changing direction rapidly, Stopping suddenly, Landing from a jump incorrectly, Direct contact or collision, such as a football tackle. There are many factors [5] causing this trauma which are broadly classifies as intrinsic and extrinsic. Intrinsic factors include muscle strength, activation of hamstrings, biomechanical forces. Weather, type and condition of the playing field, and footwear are all extrinsic risk factors. These factors have an impact on the shoe-surface interaction, which is most certainly a risk factor. Weather has been linked to an increased risk of ACL damage. It is categorised in this manner so that proper surgery and investigations may be employed.

ACL sprains are categorised as grade I, II, or III. [6] Grade I [Sprain] - The ligament fibres are strained, but there is no rupture, Tenderness and edema are present, During exercise, the knee does not feel unstable or give way, There is no additional laxity, and the ultimate result is firm. Grade II - Ligament fibres are partly ripped or incompletely torn with bleeding, There is some pain and swelling, as well as some loss of function, Lachman's and anterior drawer stress tests are painful. Grade III - The ligament fibres are totally ripped (ruptured); the ligament itself is fully torn into two pieces, There is discomfort but little pain, There might be little swelling or a lot of edema.

Investigations like Lachman test, [7] pivot shift test and magnetic resonance imaging (MRI) are done for diagnosing ACL injury. In order to obtain the best results surgical intervention is done. The surgery is mainly dependent on the graft which is being chosen. It can be autograft, allograft or even prosthetic ligaments. The end result is also dependent on the chosen graft, Irrespective of whether surgical or nonsurgical treatment is pursued, patients should be advised to ice, compress, elevate, and limit the use of the injured knee immediately [8]. Surgical reconstruction is done with autograft from donor areas like ligamentum patellae, tendon of gracilis, tendon of semitendinosus and quadriceps tendon. These grafts are selected based on the clinical presentation.

There are various factors which need to be considered before choosing a graft, these factors are:

A) The graft must be available for immediate use
B) Instant fixation of the graft must be done
C) The chosen graft must be close to the ACL ligament

The size of the graft is of utmost importance because inadequate graft diameter leads to operative difficulties. [9] These operative difficulties can be avoided by measuring the graft size pre-operatively[3]. Therefore, this article aims to determine the role of anthropometric data in assessing hamstring graft size in anterior cruciate ligament reconstruction.

2. METHODOLOGY

This was a prospective study done over the period of 1 year from August 2020 to August 2021. Patients who were scheduled to undergo ACL reconstruction surgery at the department of orthopaedics at Saveetha medical college in Thandalam were the participants in this study. This research had a sample size of 72 people.

2.1 Inclusion Criteria

1) Clinically symptomatic patients with ACL injury
2) Patients with a normal opposite knee
3) The patients who need hamstring grafting as their surgical technique
4) Patients within the age bracket of 18 to 50 years
5) Patients who need their first ACL reconstruction

2.2 Exclusion Criteria

1) Patients who are asymptomatic
2) Patients who have posterior cruciate ligament tear
3) Patients who are aged less than 18 or greater than 50 years
4) Patients who have already had an ACL surgery
5) Patients with a previous history of surgery, trauma to the ipsilateral knee
6) Patients who have diseases which affect the pre anaesthetic fitness

The subject's height was measured while standing barefoot against the anthropometric equipment, and the subject's weight was assessed while standing on the scale with minimum movement and hands positioned on the scale. Shoes and extra clothes should be removed from their sides, and thigh circumference was measured 15 cm proximal to superior pole of the patella in all patients. BMI was determined based on the patient's weight and height.

2.3 Surgical Techniques

All patients underwent single bundle reconstruction under spinal anaesthesia. A vertical incision 3 cm long was made at tibial insertion on the skin over the hamstring tendon, on pes anserinus area. After prepping and drapping, sartorius fascia was incised accompanying the superior edge of Gracilis tendon (GT) and Semitendinosus tendon (ST). These tendons were harvested by using closed tendon stripper. The ST tendon is then sized, and if the diameter is judged inadequate, the GC tendon is harvested in the same manner. Tendons were prepared in a single bundle, 4-strand technique with each end of the tendon grafts whipstitched with a No. 2 non absorbable polyester suture. The final diameter of the graft was determined by the smallest diameter allowing smooth passage in 'sizing cylinder' of Smith and Nephew with increments of 0,5 mm. Graft diameter was obtained from the largest measured portion of the graft, overall graft length needs to be at least 27 cm to ensure that the recommended 20 mm of graft is within each bone tunnel. At this point, the whipstitch is used to tension the entirety of the graft unit. Then pass the whipstitch needle through the tendon unit as it turns around the opposing suture loop. HT [quadrupled hamstring tendon] graft total length was defined as the measured end to end length of the prepared graft. All grafts were of sufficient length, with a minimum 8 cm of total graft length after quadrupled preparation.

Finally, the prepared 4-strand HT autograft was implanted and fixed. Femoral fixation was achieved with Endobutton while tibial fixation was achieved with Bioscrew.

After the graft has been properly prepared, diagnostic arthroscopy and ACL repair are performed using the surgeon's preferred approach. We employ an all-inside anatomic repair with retrodrilling of both the femoral and tibial tunnels.

2.4 Statistical Analysis

SPSS version 22.0 was used for statistical analysis. An independent-sample t-test was used to find a link between gender and intraoperative HT autograft size. Correlation coefficients (Pearson r) were used to identify the association between length of the ST and GT autografts and continuous variables (age, height, weight, BMI and thigh circumference). Higher

correlation coefficient shows stronger relationship between variables. In order to improve the matching degree of the regression equation and real parameters, we have taken log of these continuous variables. P values less than 0.05 were considered as significant.

3. RESULTS

This study consisted of 72 patients, with 63% of males and 37% females [Graph: 1].

Out of 72 patients included in the study, 19 (26.38%) patients were in the age bracket 18-25 years, 39 (54.16%) were between 26-35 years and 14 (19.44%) were in the age bracket 35-45 years. [Graph: 2].
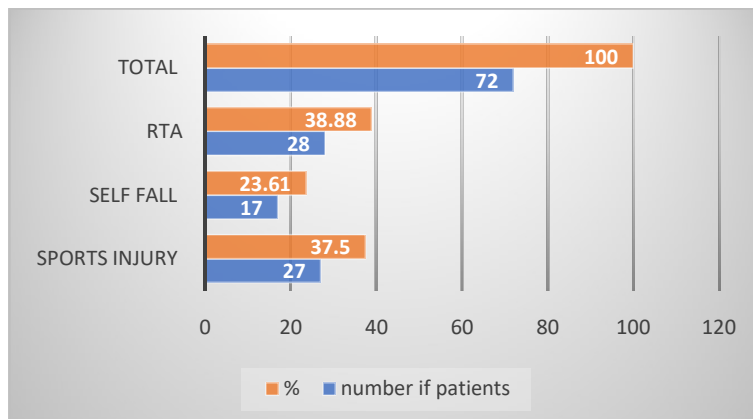
The common mode of injury was observed to be due to RTA (road traffic accident), Self fall and sports injury. In our study, 28 (38.88%) suffered the injury due to RTA, 17 (23.61%) due to self fall and 27 (37.5%) due to sports injury. [Graph: 3].
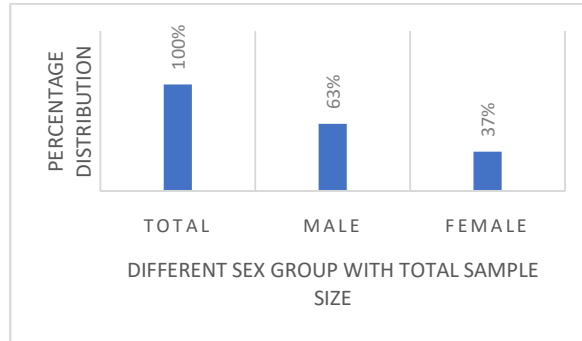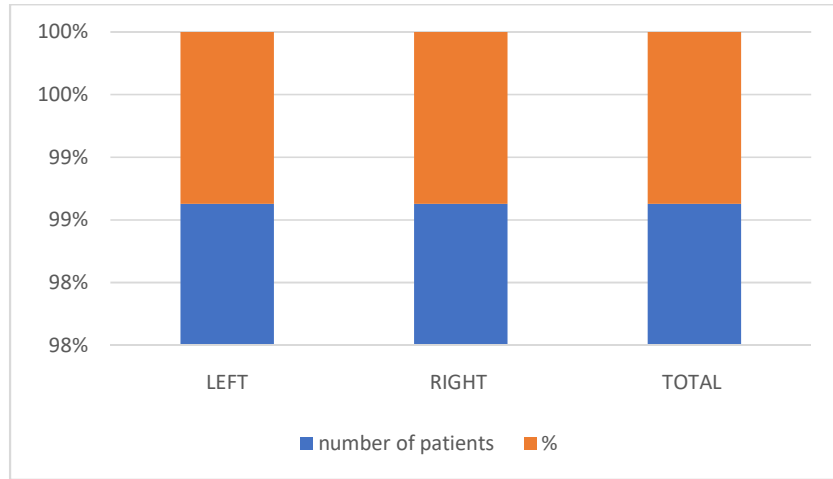
Graph 1. Sex distribution among the patients
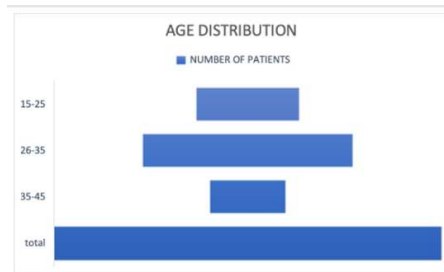
Graph 2. Age distribution among the patients

Graph 3. Mode of injury

Graph 4. Side involvement of injury

Out of the 72 patients, the total number of patients injured on their left side were 33 (45.83%)   and on the right side were 39 (54.16%). [Graph: 4].

Out of the 72 patients, 31 (44%) patients had medial meniscus injury and 40 (56%) had lateral meniscus injury. [Graph: 5].

From the above data, it was observed that 15 females and 16 males suffered from medial meniscus injury and 12 females and 29 males suffered from lateral meniscus injury

Table 1 presents the means of patients' demographics along with the mean of the anthropometric measurement taken.

Correlation coefficient (Pearson r) were used to identify the magnitude of each data correlation (Table 2) (Fig. 1). Height was shown to have a modest correlation with GT length. While thigh circumference has a modest correlation with ST length. Age, BMI, and thigh length had no relationship to any of the intraoperative measurements. Thigh circumference, on the other hand, has contributed roughly 6.5 percent of the variance in ST length. We used regression analysis to create the following prediction equations for GT length and ST length autografts based on the predictors that were substantially correlated:

1. GT length
Gt length = - 7.509 + 0.183 x height [cm]; r $^{1/4}$ 0,432
2. ST length
ST length = - 35.716 + 1.485 x TC [cm]; r $^{1/4}$ 0,255

Correlation analysis indicates that shorter height would have shorter GT length, while smaller thigh circumference would have smaller ST length.
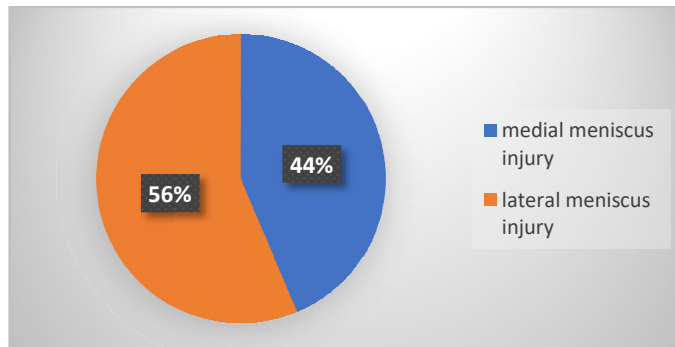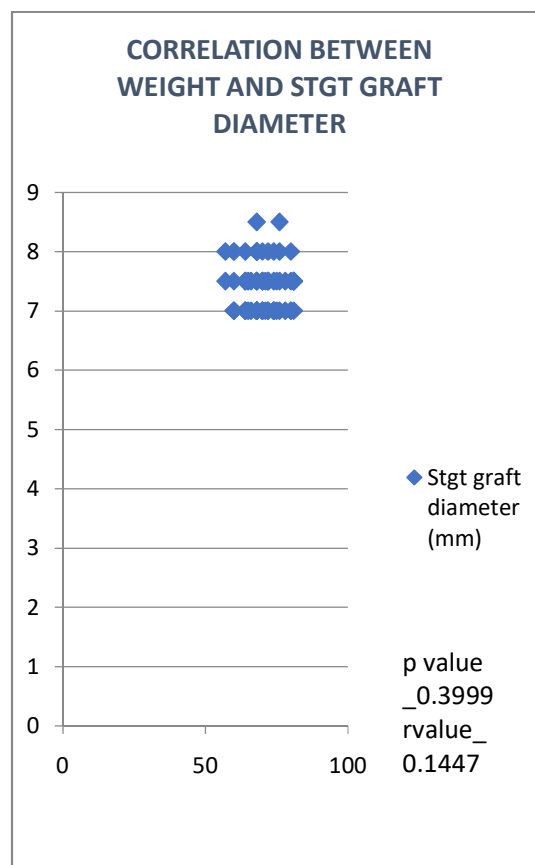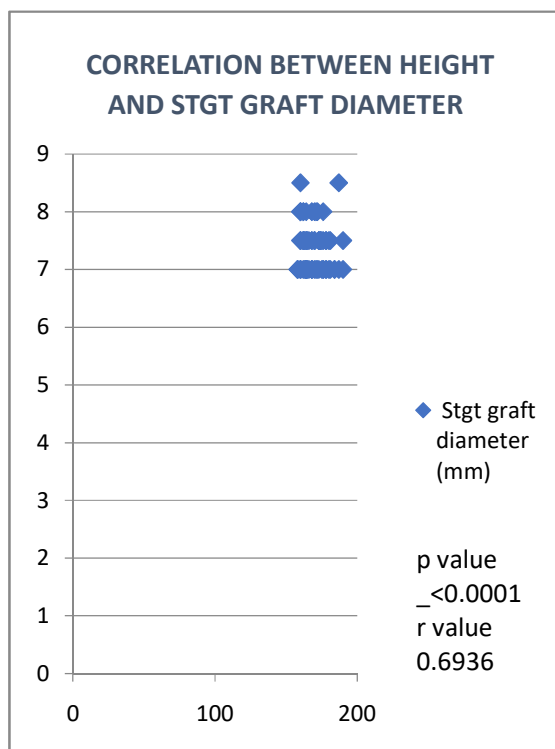

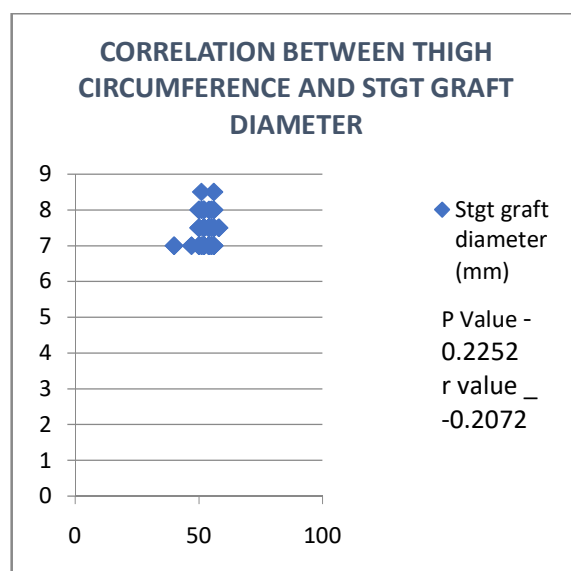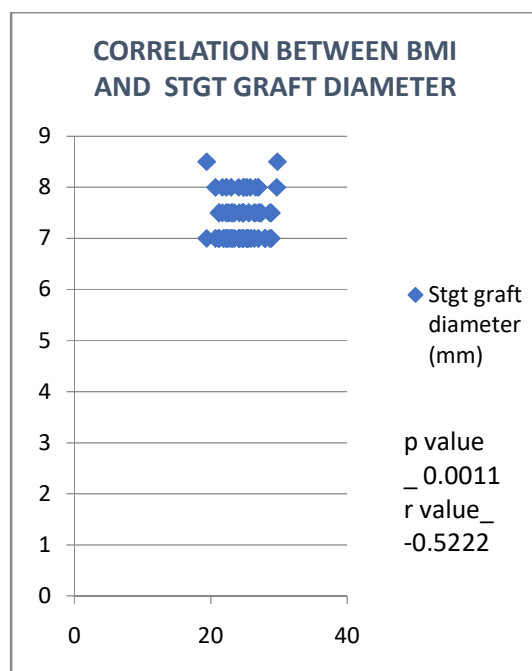**Graph 5. Side distribution of meniscal injury**

Table 1. Demographics according to mean ± SD intra –operative graft diameters

Gender	Graft diameter (mm)					
	7		**7.5**		**8**	**8.5**
	MALE	**FEMALE**	**MALE**	**FEMALE**	**MALE**	**MALE**
N [72]	21	12	19	6	12	2
Height (cms)	165.7±5	162.7±3	171.9±5.5	162	179	184
Weight (kg)	69±6	69±7	71 ± 6.5	68	71	74
Thigh circumference (cm)	53 ± 5.2	55 ±2.5	52.2±1.5	52	53.2	47

Table 2. Correlation coefficient for relationships between anthropometric parameter and intra operative measurements

	GT Length	ST Length
Age	-0.092	-0.052
Height	0.387	-0.032
Weight	0.152	0.216
BMI	-0.023	0.250
Thigh circumference	0.054	0.310

CORRELATION BETWEEN HEIGHT AND STGT GRAFT DIAMETER

Stgt graft diameter (mm)

p value _<0.0001
r value 0.6936

CORRELATION BETWEEN WEIGHT AND STGT GRAFT DIAMETER

Stgt graft diameter (mm)

p value _0.3999
rvalue_ 0.1447

CORRELATION BETWEEN BMI AND STGT GRAFT DIAMETER

◆ Stgt graft diameter (mm)

p value _ 0.0011
r value_ -0.5222

CORRELATION BETWEEN THIGH CIRCUMFERENCE AND STGT GRAFT DIAMETER

◆ Stgt graft diameter (mm)

P Value - 0.2252
r value _ -0.2072

Fig. 1. Correlation coefficients for relationships between anthropometric parameters

4. DISCUSSION

The most important finding of the present study is that the diameter of hamstring tendon autografts can be predicted by anthropometric parameters. In this study, the number of samples was 72 with the minimum length of the ST obtained was 20 cm and the minimum length of the GT was 16 cm, so that the graft length would become approximately 8cm when using a quadruple graft.

Despite Magnussen et al. [10] recommended GT autograft diameter should have diameter of 8 mm or more to avoid the risk of revision. Bear in mind that biomechanical consideration is an important factor that influences the size of the raft diameter, thus patients within adequate risk of

graft diameter and length were advised to use other autograft options, such as peroneus longus tendon (PLT) [11].

This study reveals that Gracilis Tendon [GT] length correlates with height (r $^{1/4}$ 0,432), and Semi Tendinous [ST] length correlates with thigh circumference (r $^{1/4}$ 0,255). Whereas age, gender, BMI, and thigh length have no correlation to graft size. In our study, we found that patients shorter than155 cm in height are likely to have autograft diameter less than 7 mm.

Previous studies [12,13] found that anthropometric measurements such as age, gender, height, weight, BMI, thigh circumference, thigh length, patient's Tegner score and smoking status correlated with the length and diameter of the HT autograft. Also they found that height, weight and gender have moderate correlation to graft diameter (r ¼ 0,38 and r ¼ 0,29, and r ¼ _0,28,respectively).

The anthropometric parameters of the study subjects (E.g. Weight and Height of tendon size (E.g. Cross sectional area of tendons) were positively (P<0.05) associated with graft diameter when measured intra -operatively [3]. From previous studies it has been concluded that this association is corresponding to the prediction of diameter of the graft (Conte et al., 2014) [14].

Further, a study from Bickel et al., [7] observed a significant correlation between the sum of the semitendinosus and gracilis areas measured on MRI with values above 18 mm^2 and the achievement of a suitable-sized graft in 88% of cases. In another study, Wernecke et al. [15] examined the area of the tendons of 34 patients on MRI and recommended a 10 mm^2-area for the gracilis tendon and a 17 mm^2-area for the semitendinosus tendon to obtain a suitable sized graft, considering a quadruple graft.

In contrast to the current study, Sakti et al., 2019 discovered that 83.33 percent of all patients had graft diameters of 7 mm or more. Height and TLL are related to GT length and quadruple HT autograft diameter, respectively, whereas thigh circumference is related to ST length. [16] Similarly other study by Goyal et al., 2016 [17] identified 96% of the grafts had a diameter of 7 mm or more [3]. Height and thigh length were shown to be the most substantially related to both harvested tendon length and quadrupled graft diameter (p ≤ 0.001, r = 0.25–0.39). Patients with a height of less than 147 cm were shown to be at the highest risk of having an insufficient graft diameter (less than 7 mm). Although the anthropometric characteristics were discovered to be substantially associated to height and thigh length, the strength of the connection was determined to be modest.

5. CONCLUSION

The ability to anticipate transplant characteristics before to surgery is certainly helpful. Several studies have shown that common anthropometric factors such as height are helpful. However, this study discovered that the patient's weight and thigh circumference, as well as BMI, were strong predictors of quadruple diameter and length of the graft. Hence, these results provide preliminary support for the use of some anthropometric measurements in the preoperative planning and prediction of the hamstring graft length and diameter in anterior crucial ligament reconstruction.

CONSENT AND ETHICAL APPROVAL

As per international standard or university standard guideline Patient's consent and ethical approval has been collected and preserved by the authors.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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