Original Research Article

MRI study of age related changes in a meniscus

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Abstract

Background: The purpose of this study was to determine age related changes in menisci using dimensions of menisci on MRI. The standard dimensions of lateral and medial menisci help us to determine age related changes, and this may be important for planning surgical interventions.
Materials and methods: 100 Indian patients with history of knee pain were subjected to MRI. None of the patients had any pathological signal intensity suggesting meniscal tear. Patients were scanned in supine position with knees extended. All patients were studied in sagittal and coronal planes. The Anterior horn, Posterior horn and Mid-body of menisci were examined in sagittal and coronal plane for the following parameters. Height and width of anterior and posterior horn of lateral and medial meniscus on sagittal plane and height and width of mid-body of lateral and medial menisci on coronal plane were examined. Height and width of anterior and posterior horn were measured on sagittal plane where the highest and widest meniscal size was observed. The mid-body was measured at the level of inter condylar eminence, in the coronal plane. The total data of 100 patients collected, was numbered as per the ascending order of age. The relationship between age and meniscal parameters of the cases was evaluated in this study by using correlation analyses. Correlation was significant at the 0.01 level (2-tailed). The tests were applied and graphically represented. The SPSS 10.0 program was used for statistical analyses. Data are presented as mean $\pm$ SD.
Results: We found that, more meniscal tears were seen where height and width of meniscus was less. In a particular age group where height and width was less, early signs of osteoarthritis should be predicted. This study shall be useful for tissue banks and surgeons, for meniscal sizing during transplantation in a particular age group.
Conclusion: It was observed that as age increases, significant decrease was seen in height of anterior horn of medial meniscus, height and width of posterior horn of both the meniscus, and width of anterior horn of lateral meniscus.

Key words

Knee joint, Meniscus, Inter condylar eminence.

Introduction

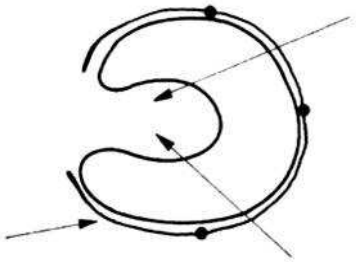
The knee joint is formed by condyles of femur and tibia and posterior articular surfaces of patella. The purpose of this study is to establish age related changes in menisci using measurements of normal menisci by MRI. For this purpose the height and width of the medial and lateral meniscus is measured. To establish these standard measurements, we had calculated the height and the width of medial meniscus and lateral meniscus in sagittal and coronal plane. In sagittal plane, anterior and posterior horns of the same meniscus are seen. So, height and width of anterior and posterior horns were calculated in sagittal plane. The height and width of mid body of both menisci were best seen in the coronal plane. So, it was calculated in coronal plane.

Materials and methods

100 Indian patients with age above 10 years with history of knee pain were subjected to MRI with an AIRIS II HITACHI model. Patients with non-specific knee ache were included in the study. None of the patients had any pathological signal intensity suggesting meniscal tear. Handedness and gender of the patient were not considered in this study. Patients were scanned in supine position with knees extended. All patients were studied in sagittal and coronal planes with multi-slice, spin-echo (T1 weighted acquisition) and fast scan (T2-weighted images) techniques. Sagittal and coronal spin-echo T1-weighted images were acquired using the following parameters: 460/26 (TR/TE), slice thickness 3 mm.T2-weighted images were also acquired using the following parameters: 450/15 (TR/TE), slice thickness 3 mm. For the purpose of study each meniscus was divided into three zones: anterior horn, posterior horn, and mid-body as per **Figure – 1** [1].

In order to study, sections were taken in sagittal and coronal plane. The height and width of anterior horn and posterior horn of menisci were measured in sagittal plane where the highest and widest meniscal sizes were observed. The mid-body was measured at the level of inter condylar eminence. The height and width of mid-bodies were best evaluated in the coronal plane [2]. All the dimensions were taken in millimetres. The required images were saved on the machine. These were later transferred on a CD and a soft copy was made.

Figure – 1: Diagram representing the three zones of menisci: anterior, middle and posterior [1].



The anterior horn, posterior horn and mid-body of menisci were examined in sagittal and coronal plane for the following parameters.

- Height of anterior horn and posterior horn of the lateral and the medial meniscus in the sagittal plane.
- Width of anterior horn and posterior horn of the lateral and the medial meniscus in the sagittal plane. (**Figure – 2A, 2B, Figure - 3A, 3B**)
- Height of mid-body of the lateral and medial meniscus in the coronal plane.
- Width of mid-body of the lateral and medial meniscus in the coronal plane. (**Figure – 4A, 4B**)

Statistics

The total data of 100 patients collected, was numbered as per the ascending order of age, and thus the master chart was made. The patients were later grouped and statistically evaluated for justifying the aim and objectives. The relationship between age and meniscal parameters of the cases was evaluated in this

study by using correlation analyses. Correlation was significant at the 0.01 level (2-tailed). The test were appropriately applied and graphically represented. The SPSS 10.0 program was used for the purpose of statistical analyses. Data are presented as mean ± SD. The data collection was completed within the stipulated time given by the Ethics committee. After having done with the final formalities, the data was compiled together.

Figure – 2A, 2B: Measuring height and width of lateral meniscus.

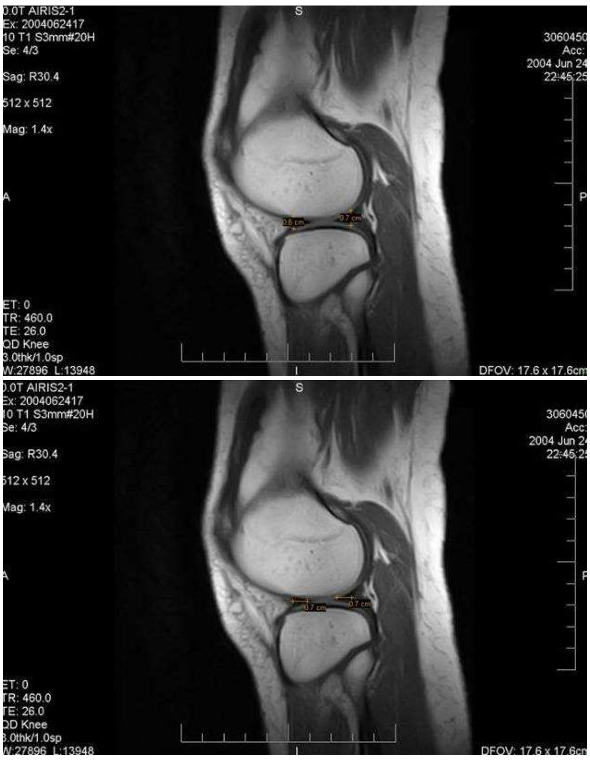


Figure – 3A, 3B: Measuring height and width of medial meniscus.

Figure – 4A, 4B: Measuring height and width of mid body of both the meniscus.

Results

The collected data was first arranged by their ascending age. The relationship between age and meniscal parameters of the cases was evaluated in this study by using correlation analyses. The SPSS 10.0 program was used for the purpose of statistical analyses. Data are presented as mean ± SD.

The dimensions of the medial meniscus and lateral meniscus were summarized as per **Table – 1** and **Graph - 1**. Correlation of age with height of anterior horn of medial meniscus and lateral meniscus was as per **Table – 2** and **Table - 3**.

Mean of height of mid body of medial and lateral meniscus was as per **Table – 4** and **Graph - 2**. Correlation of age with height of mid body of medial and lateral meniscus was as per **Table – 5** and **Table – 6.** Mean of height of posterior horn of medial and lateral meniscus was as per **Table – 7** and **Graph - 3**. Correlation of age with height of posterior horn of medial and lateral meniscus was as per **Table – 8** and **Table – 9**. Mean of width of anterior horn of medial and lateral meniscus was as per **Table – 10** and **Graph – 4**. Correlation of age with width of anterior horn of medial and lateral meniscus was as per **Table – 11** and **Table – 12**. Mean of width of mid body of medial and lateral meniscus was as per **Table – 13** and **Graph – 5**. Correlation of age with width of mid body of medial and lateral meniscus was as per **Table – 14** and **Table – 15**. Mean of width of posterior horn of medial and lateral meniscus was as per **Table – 16** and **Graph – 6**. Correlation of age with width of posterior horn of medial and lateral meniscus was as per **Table – 17** and **Table – 18**.

Table - 1: Mean of height of anterior horn of medial and lateral meniscus.

RAGE	MAHH1	LAHH2
10-20	7.125	5.4375
21-30	7.125	5.4375
31-40	6.1	5.1
41-50	5.5	5.35
51-60	4.75	5.333333
60+	3.5	4.75

(**MAHH1:** Medial meniscus anterior horn height, **LAHH2:** Lateral meniscus anterior horn height)

Discussion

Meniscal lesions are among the most common knee disorders encountered by the practicing orthopedic surgeon. Total meniscectomy has been shown to be detrimental to the knee, and most surgeons recommend meniscal repair or partial meniscectomy for meniscal tears. The menisci have important functions in load bearing, shock absorption, joint stability, joint congruity and joint nutrition. The meniscus is a secondary stabilizer of the knee and aids in proprioception. The absence of one of the menisci and the subsequent loss of function may lead to early arthritis and pain.

Table – 2: Correlation of age with height of anterior horn of medial meniscus.

Correlations			
		RAGE	**MAHH1**
RAGE	**Pearson Correlagbtion**	1.000	-.796(**)
	Sig. (2-tailed)	.	.000
	N	100	100
MAHH1	**Pearson Correlation**	-.796(**)	1.000
	Sig. (2-tailed)	.000	.
	N	100	100
** Correlation is significant at the 0.01 level (2-tailed).			

Table – 3: Correlation of age with height of anterior horn of lateral meniscus.

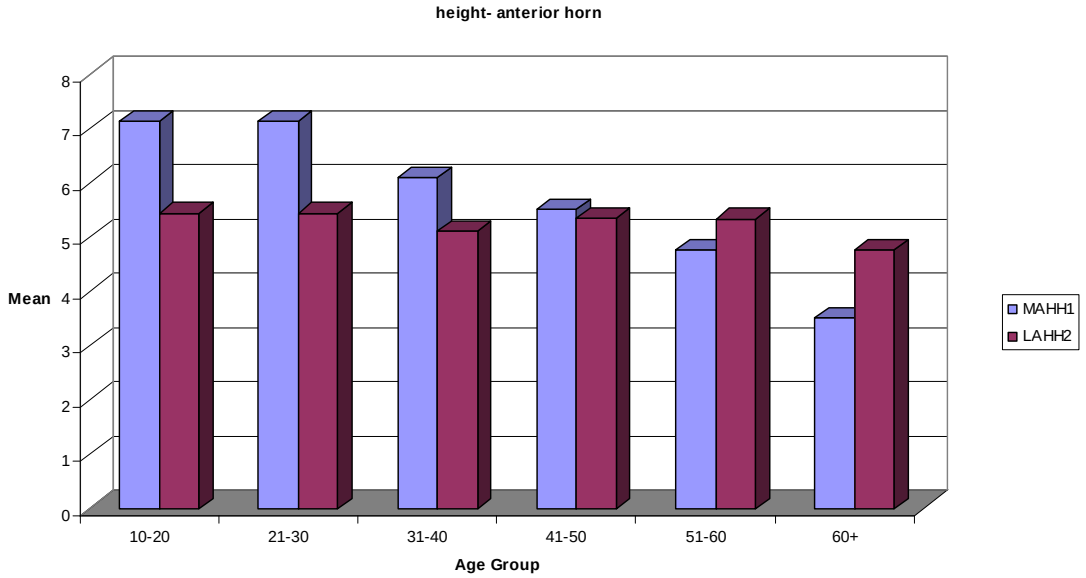
Correlations			
		RAGE	**LAHH2**
RAGE	**Pearson Correlation**	1.000	-.120
	Sig. (2-tailed)	.	.233
	N	100	100
LAHH2	**Pearson Correlation**	-.120	1.000
	Sig. (2-tailed)	.233	.
	N	100	100

Table – 4: Mean of height of mid body of medial and lateral meniscus.

RAGE	MMBH1	LMBH2
10-20	5.3125	5.25
21-30	5.3125	5.25
31-40	4.9	5
41-50	5.65	5.3
51-60	5.708333	5.708333
60+	4.25	4.75

(**MMBH1:** Medial meniscus mid body height, **LMBH2:** Lateral meniscus mid body height)

Graph - 1: Height of anterior horn.



Graph - 2: Height of mid body.

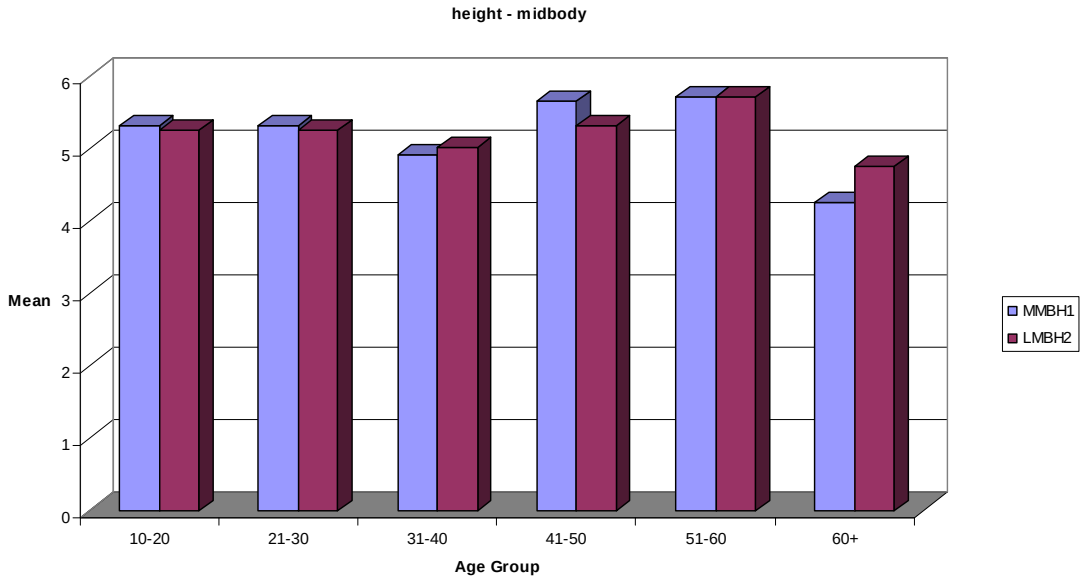


Table – 5: Correlation of age with height of mid body of medial meniscus.

Correlations			
		RAGE	**MMBH1**
RAGE	**Pearson Correlation**	1.000	.118
	Sig. (2-tailed)	.	.240
	N	100	100
MMBH1	**Pearson Correlation**	.118	1.000
	Sig. (2-tailed)	.240	.
	N	100	100

Over the past few decades, adverse effects of total meniscectomy have led surgeons to change the way they approach repair of meniscal pathology. In 1978, Smillie, recommended complete meniscectomy for the treatment of most meniscal tears. Clinical studies have shown complete removal of the meniscus to be harmful to the function of the knee and it increases mechanical wear on the knee. Studies of anatomy and biomechanical properties of the meniscus have increased the understanding of their role in normal knee function. Surgical philosophy has

now matured from routine excision to preservation and even restoration.

Table – 6: Correlation of age with height of mid body of lateral meniscus.

Correlations			
		RAGE	**LMBH2**
RAGE	**Pearson Correlation**	1.000	.170
	Sig. (2-tailed)	.	.091
	N	100	100
LMBH2	**Pearson Correlation**	.170	1.000
	Sig. (2-tailed)	.091	.
	N	100	100

Table – 7: Mean of height of posterior horn of medial and lateral meniscus.

RAGE	MPHH1	LPHH2
10-20	6.375	6.125
21-30	6.375	6.125
31-40	5.85	5.1
41-50	5.95	5.6
51-60	5.541667	5.583333
60+	4.5	4

(**MPHH1:** Medial meniscus posterior horn height, **LPHH2:** Lateral meniscus posterior horn height)

Table – 8: Correlation of age with height of posterior horn of medial meniscus.

Correlations			
		RAGE	**MPHH1**
RAGE	**Pearson Correlation**	1.000	-.456(**)
	Sig. (2-tailed)	.	.000
	N	100	100
MPHH1	**Pearson Correlation**	-.456(**)	1.000
	Sig. (2-tailed)	.000	.
	N	100	100
** Correlation is significant at the 0.01 level (2-tailed).			

Table – 9: Correlation of age with height of posterior horn of lateral meniscus.

Correlations			
		RAGE	**LPHH2**
RAGE	**Pearson Correlation**	1.000	-.379(**)
	Sig. (2-tailed)	.	.000
	N	100	100
LPHH2	**Pearson Correlation**	-.379(**)	1.000
	Sig. (2-tailed)	.000	.
	N	100	100
** Correlation is significant at the 0.01 level (2-tailed).			

Table – 10: Mean of width of anterior horn of medial and lateral meniscus.

RAGE	MAHW1	LAHW2
10-20	6.5	9.5
21-30	6.5	9.5
31-40	5.35	7.35
41-50	6.2	8.05
51-60	6.25	8.125
60+	5.25	8.25

(**MAHW1:** Medial meniscus anterior horn width, **LAHW2:** Lateral meniscus anterior horn width)

Table – 11: Correlation of age with width of anterior horn of medial meniscus.

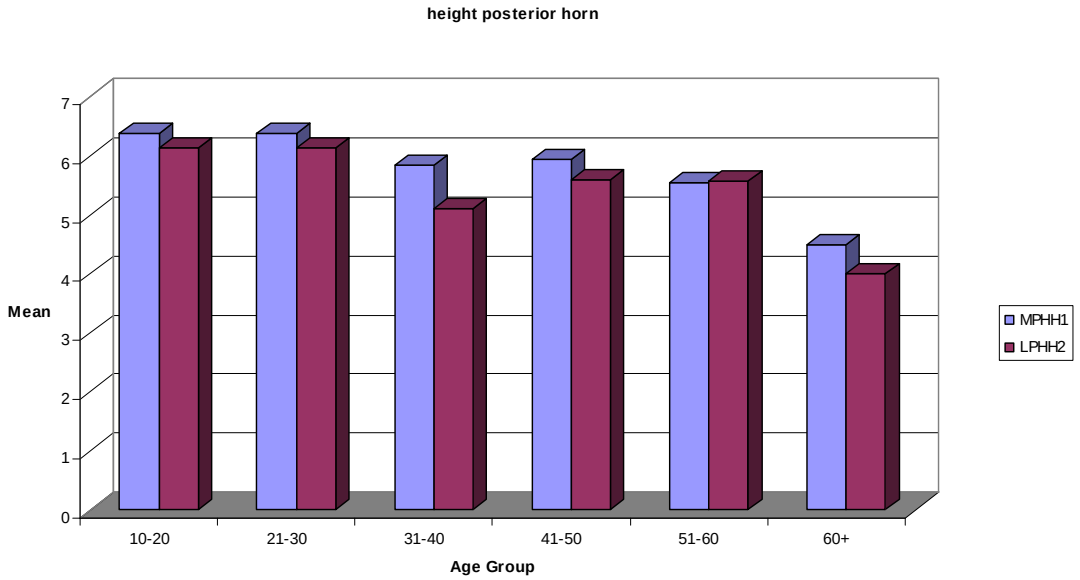
Correlations			
		RAGE	**MAHW1**
RAGE	**Pearson Correlation**	1.000	-.142
	Sig. (2-tailed)	.	.158
	N	100	100
MAHW1	**Pearson Correlation**	-.142	1.000
	Sig. (2-tailed)	.158	.
	N	100	100

Meniscal allograft reconstruction

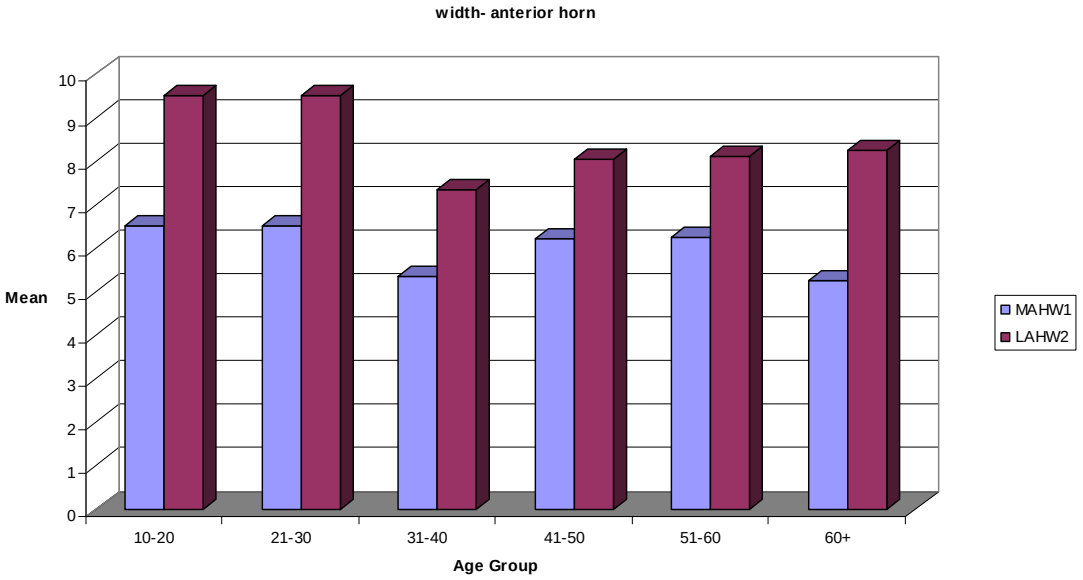
Meniscal transplant was first performed in 1984 by Milachowski and colleagues [3], who inserted 24 fresh-frozen transplant menisci into the medial compartments of patients who had

previously undergone total meniscectomy. Evolution of the technique was slow, because fresh menisci were difficult to come by. Two other studies conducted in the late '80s and early '90s proved that transplanted menisci could heal after transplantation without incidence of an immune antibody response. Researchers have attempted synthetic substitutes and collagen scaffolds with mixed success [4, 5].

Graph - 3: Height of posterior horn.



Graph - 4: Width of anterior horn.



Meniscal transplantation has evolved over the past 10 years as a promising technique. The recognition that meniscal sacrifice leads to early onset of degenerative arthritis has led investigators to search for techniques to alter the long-term consequences of complete or subtotal meniscectomy. Meniscal allograft transplantation intends to restore meniscal function through increase of contact area, decrease in contact stress, joint stabilization, shock absorption and lubrication.

Table – 12: Correlation of age with width of anterior horn of lateral meniscus.

Correlations			
		RAGE	**LAHW2**
RAGE	**Pearson Correlation**	1.000	-.422(**)
	Sig. (2-tailed)	.	.000
	N	100	100
LAHW2	**Pearson Correlation**	-.422(**)	1.000
	Sig. (2-tailed)	.000	.
	N	100	100
** Correlation is significant at the 0.01 level (2-tailed).			

Table – 13: Mean of width of mid body of medial and lateral meniscus.

RAGE	MMBW1	LMBW2
10-20	6.9375	7.5
21-30	6.9375	7.5
31-40	5.1	6.6
41-50	6.3	7.15
51-60	6.541667	7.666667
60+	5.75	7.25

(**MMBW1:** Medial meniscus mid body width, **LMBW2:** Lateral meniscus mid body width)

Table – 14: Correlation of age with width of mid body of medial meniscus.

Correlations			
		RAGE	**MMBW1**
RAGE	**Pearson Correlation**	1.000	-.133
	Sig. (2-tailed)	.	.187
	N	100	100
MMBW1	**Pearson Correlation**	-.133	1.000
	Sig. (2-tailed)	.187	.
	N	100	100

The meniscal allograft is harvested and procured according to standards established by the American Association of Tissue Banks [6] and is typically fresh frozen. Precise sizing of the meniscal allograft is correlated by true lateral x-ray measurement of the anterior posterior width of the tibial plateau [7]. MRI sizing of the contralateral intact meniscus better predicts needed size for meniscal-allograft-transplantation than recipient tibial plateau radiographs.

Table – 15: Correlation of age with width of mid body of lateral meniscus.

Correlations			
		RAGE	**LMBW2**
RAGE	**Pearson Correlation**	1.000	.040
	Sig. (2-tailed)	.	.694
	N	100	100
LMBW2	**Pearson Correlation**	.040	1.000
	Sig. (2-tailed)	.694	.
	N	100	100

Table – 16: Mean of width of posterior horn of medial and lateral meniscus.

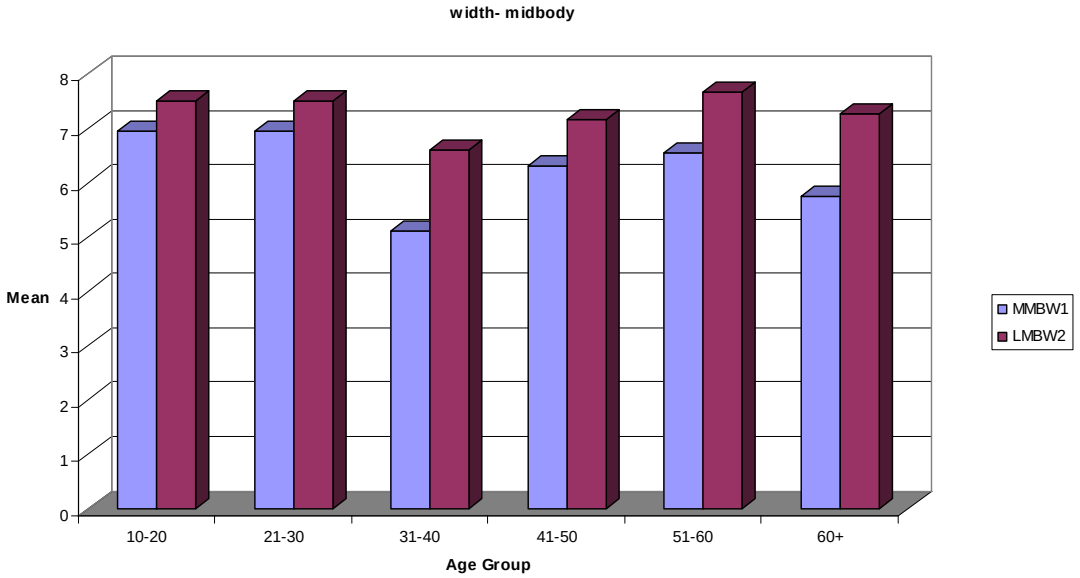
RAGE	MPHW1	LPHW2
10-20	10.3125	7.75
21-30	10.3125	7.75
31-40	8.45	5.75
41-50	7.75	6.6
51-60	7.25	6.75
60+	5.5	6.25

(**MPHW1:** Medial meniscus posterior horn width, **LPHW2:** Lateral meniscus posterior horn width)

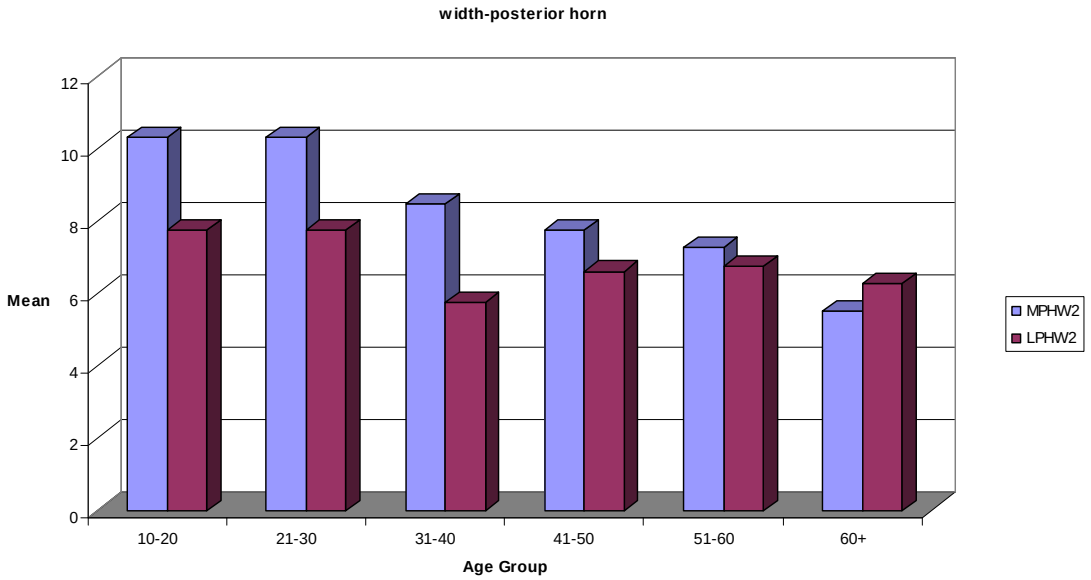
Table – 17: Correlation of age with width of posterior horn of medial meniscus.

Correlations			
		RAGE	**MPHW1**
RAGE	**Pearson Correlation**	1.000	-.796(**)
	Sig. (2-tailed)	.	.000
	N	100	100
MPHW1	**Pearson Correlation**	-.796(**)	1.000
	Sig. (2-tailed)	.000	.
	N	100	100
** Correlation is significant at the 0.01 level (2-tailed).			

Graph - 5: Width of mid body.



Graph - 6: Width of posterior horn.



Currently the needed size of a meniscus for meniscal-allograft- transplantation (MAT) is estimated from recipient tibial plateau radiographs. The authors have found this method to be frequently inaccurate, often overestimating the needed size. In arthritic knees, transplanted menisci usually fail by extrusion, if oversized. MRI measurement of a patient's contralateral intact meniscus offers a potentially more accurate method to determine ipsilateral meniscal size [8]. Currently, the search is under way for a synthetic meniscal replacement.

Meniscal regeneration

The biomechanical properties of the naturally occurring meniscus provide an enormous challenge for any synthetic material to match. One meniscal replacement strategy focuses on regeneration of meniscal tissue. The theory of meniscal regeneration is based on similar scenarios for skin regeneration in burn patients, as well as nerve regeneration. In the case of meniscal regeneration, a collagen scaffold acts as a resorbable regeneration template, where the scaffold resorbs at a controlled rate to allow for

meniscal regeneration. Clinical studies investigating this technique are ongoing [9, 10].

Table – 18: Correlation of age with width of posterior horn of lateral meniscus.

Correlations			
		RAGE	**LPHW2**
RAGE	**Pearson Correlation**	1.000	-.338(**)
	Sig. (2-tailed)	.	.001
	N	100	100
LPHW2	**Pearson Correlation**	-.338(**)	1.000
	Sig. (2-tailed)	.001	.
	N	100	100
** Correlation is significant at the 0.01 level (2-tailed).			

Currently, meniscal allograft transplantation, as well as meniscal regeneration, remains areas of clinical research. As such, these topics remain controversial and there is no consensus opinion with regard to their widespread clinical application.

Osteoarthritis (OA)

Osteoarthritis (OA) is the most common form of arthritis. OA has a significant impact on function, activities of daily living, work and function within society. Its prevalence rises with age [11]. With an aging society, its impact will continue to grow. Damage to the meniscus, increases the risk of cartilage loss in patients with osteoarthritis of the knee, according to a report in New York (Reuters Health). "The meniscus performs an important function in the joint and removing it (either in part or whole) will only enhance the rate of structural change within the joint," Dr. David J. Hunter from Boston University School of Medicine, Massachusetts told Reuters Health. Hunter and colleagues explored the role of meniscal tears and meniscal malposition as risk factors for cartilage loss in 257 men and women with knee osteoarthritis. Each measure of meniscal malposition was associated with an increased risk of cartilage loss, the authors report. Meniscal damage was also strongly associated with cartilage loss.

The investigators write in the journal of Arthritis and Rheumatism [12] that the meniscus plays an important role to prevent further cartilage loss. Joint injury causes knee osteoarthritis in young adults [13]. Until recently, radiographic change has been the accepted way in which to assess structural change in OA, using joint space narrowing as a proxy for articular cartilage. However, recently, magnetic resonance imaging (MRI) has been used to measure meniscus non-invasively [14, 15, 16].

As we get older, the meniscus weakens and tears can occur more easily, even from something as simple as squatting or stepping on an uneven surface. These tears can even occur as a gradual result of a degenerative condition such as osteoarthritis, rather than as the result of a specific injury. Clinical studies have shown that altered load bearing in a meniscal deficient knee leads to degenerative changes and altered mechanics [17, 18]. Fairbank and associates have delineated and categorized degenerative changes in articular cartilage after meniscectomy.

Conclusion

The MRI study was conducted on Indian patients aged above 10 years and with history of knee pain. After analyzing the data statistically and representing it graphically following results were seen. It was observed that as age increases, significant decrease was seen in height of anterior horn of medial meniscus, height and width of posterior horn of both the meniscus, and width of anterior horn of lateral meniscus. Not significant changes were also seen in height of mid-bodies of meniscus, width of mid-bodies of both the meniscus, height of anterior horn of lateral meniscus, and width of anterior horn of medial meniscus. We have thus evaluated the relationship between age and meniscal parameters of the cases. We found that, more meniscal tears were seen where height and width of meniscus was less [19]. Also, in a particular

age group where height and width was less, early signs of osteoarthritis should be predicted. This study shall also be useful for tissue banks and surgeons, for meniscal sizing during transplantation in a particular age group. This study can be considered as a basic tool for further detailed analysis on meniscal parameters such as gender and weight. At present we are working on weight related changes in a meniscus.

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