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Original Article

Dentistry Section

A Morphometric Analysis of Intra-articular Disc of Temporomandibular Joints in Cadavers

PRATIK ASHOKKUMAR AGRAWAL[1], NAVIN S SHAH[2], RAMNARAYAN A GANDOTRA[3], KARAN VASANTRAY PANCHAL[4], RISHABH NAVIN SHAH[5]

ABSTRACT

Introduction: Temporomandibular Joint (TMJ) has been a controversial topic in Oral and Maxillofacial Surgery speciality especially regarding temporomandibular joint disorders and internal derangement of articular disc. The aetiology behind it has been related to the anatomic variations of the disc and its impact on the functioning of the articular disc. To understand such anatomic variation, the study has been conducted that will help future maxillofacial surgeon's in designing accurate prosthetic articular disc that will improve the overall mechanics of the functioning of the prosthetic disc.

Aim: To analyse the morphometric variations of the intra-articular disc in terms of circumference of the disc, perforations and their thickness within the disc in cadavers.

Materials and Methods: The present observational study was carried out on cadavers in the Department of Anatomy. SBKS Medical College and Research Centre, Sumandeep Vidyapeeth University, Gujarat, India. The study was done from January 2017 to October 2018. Temporomandibular joints were dissected bilaterally from 10 human cadavers, i.e., 20 articular discs. The disc was removed and was measured with the help of thread, vernier callipers and standardised metallic scale and the circumference and thickness in the disc were evaluated. Descriptive statistical test was used and Chi-square test was applied.

Results: Mean thickness of disc, both in males as well as females ranged from 1.4-2.0 mm in the Posterio-Medial (PM) and Posterio-Lateral (PL) region, while in Anterio-Medial (AM) and Anterio-Lateral (AL) region it ranged from 1.6-1.8 mm. Maximum length of disc ranged from 12-13 mm in anterio-posterio dimension while in Medio-Lateral (ML) it was 22-23 mm.

Conclusion: The study gives an indepth knowledge about the various morphometric variations of articular disc and also shows its impact on the functioning of the disc. The study also directs maxillofacial surgeons to design prosthetic articular disc with greater accuracy and anatomical knowledge so that the procedures like surgical replacement of the disc can be carried out with greater potency and efficacy for the betterment of the patient.

Keywords: Articular surface variations, Bilateral diarthroidial joint, Perforations, Thinning of disc

INTRODUCTION

Temporomandibular Joint (TMJ) is a multiplex, bilateral diarthroidial, ginglymoarthroidal, synovial or a compound joint acquiring the anatomical position between the squamous part of temporal bone and the head of the mandibular condyle. TMJ is quite superficial and it lies below the posterior end of the zygomatic arch just anterior of the external acoustic meatus. It is unique because it's both articular surfaces are non congruent and non co-extensive; hence there is the presence of intra-articular disc [1-3].

The articular disc appears to be the posterior extension of the lateral pterygoid muscle. As viewed from the sagittal direction the articular disc can be observed in 3 distinct zones according to the thickness. Rees JC in 1954 suggested that the central most regions is the thinnest zone and is known as the intermediate zone of about 1 mm in thickness, the anterior part which is considerably thick of about 2 mm and the posterior band of the disc which is the thickest of all of about 3mm in thickness [4-6].

The synovial joint is enclosed in a thin sleeve of fibrous tissue which blends the periosteum of the mandible and envelops the articular disc and is known as the temporomandibular joint capsule or the capsular ligament. The capsule defines the anatomical and functional boundaries of the TMJ [7-11]. Usually the disk is displaced anteriorly, and frequently there is an associated perforation of the posterior attachment of the disk [12]. There are no proved aetiologic factors for internal derangements of the temporomandibular joint. Proposed aetiologic factors include jaw trauma, muscle hyperactivity, hyperextension of the mandible, missing posterior teeth, and occlusal discrepancies [13-18].

There has also been limited data about the anterior and posterior attachments of the disc about how the attachments vary between lateral, central and medial regions of the joint [19]. The relationship between disc surface irregularities and disc displacement may not be as simple as previously thought and further studies are needed to fully understand the relationship between remodelling, disc displacement, and degenerative changes [20-24]. Therefore the need of this study is to establish a baseline data regarding the exact morphometric anatomy of the intra-articular disc of temporomandibular joint which is unavailable in the present literatures regarding the anatomy of articular disc so that with the help of this data more treatment options will be available to the surgeons such as surgical replacement of the disc can be made possible by knowing the accurate anatomy of the disc giving the patients more accurate functioning of the prosthetic disc [25-27].

The aim of the study was to analyse the morphometric variations of the disc, in terms of thickness, circumference, dimensions and perforation in the disc in human cadavers. The objectives of the study were:

1) To establish the baseline data regarding the thickness in anterior, posterior, medio-lateral and central part of the disc.
2) To evaluate the stress bearing areas of the disc.
3) To evaluate the dimensions of the disc in anterio-posterior and medio-lateral diameters.
4) To evaluate the perforations of the disc in anterior, posterior and central part of the disc.
5) To evaluate the anatomical variations in left and right articular disc of the same individual cadaver.

6) To evaluate the anatomical variations of the articular disc amongst male and female cadavers.

7) To evaluate the circumference of the disc.

MATERIALS AND METHODS

This observational study was carried out in the Department of Anatomy, SBKS Medical College and Research Centre, Sumandeep Vidyapeeth University, Gujarat, India, from January 2017 to October 2018.

Sample size calculation: A sample size of 10 was achieved by the following formula

$n=z^2\times\sigma^2/MOE^2$

n: sample size

z: found by using a z-score table

σ: population standard deviation

MOE: Margin of Error

'n' without correction equals the quantity 0.66 squared times 23 squared all over 5 squared, and rounded upto the nearest whole number. =9.217, which rounds upto 10. With a margin of error of ±5% and a population standard deviation of 23, the sample size would need to be 10.

Temporomandibular joints were dissected bilaterally in 10 human cadavers available in the Department of Anatomy. The details of the cadaveric subjects are given under [Table/Fig-1].

Subjects	Age (years)	Sex	Dentition
1.	57	Male	Partially dentulous
2.	60	Female	Partially dentulous
3.	60	Male	Partially dentulous
4.	62	Male	Partially dentulous
5.	65	Male	Partially dentulous
6.	60	Male	Partially dentulous
7.	60	Male	Partially dentulous
8.	65	Female	Partially dentulous
9.	64	Male	Partially dentulous
10.	63	Male	Partially dentulous

[Table/Fig-1]: Details of the cadaveric subjects.

Statement of human and animal rights: The Human Cadaveric dissection was carried out after the approvals granted by the Institutional Ethics Committee bearing referenced number as SVIEC/DENT/ON/BNPG16/D17009 and also from the Head of the Department of Anatomy. The dissections were carried out according to the ethical standards of the committee.

Dissection Steps [27]

Preauricular incision and approach

Step 1: Preauricular incision was made through the skin and subcutaneous tissue upto the superficial temporal fascia. Dissection was carried out above the zygomatic arch to the level of the superficial layer of the temporalis fascia. After that the dissection proceeds abruptly below the zygomatic arch, along the external auditory meatus [Table/Fig-2].

Step 2: An Oblique incision was made through the superficial layer of the temporalis fascia.

Step 3: With the help of a periosteal elevator periosteum of the arch was stripped off and dissection was done superficial to capular ligament of TMJ.

Step 4: An upright incision was made through the prevailing tissues in front of the external auditory meatus upto the periosteal elevator.

Step 5: The tissues were stretched apart and the temporomandibular joint capsule was encountered.

Step 6: The capsule was cut laterally, exposing the superior compartment of the disc. After that the cut was made medially and posteriorly till the glenoid (mandibular) fossa was been exposed [28,29].

Step 7: The disc and the condylar neck were separated from the muscles by making an additional incision through the two head of the lateral pterygoid muscles. The actual incision was continued posterio-medially through the attachments of the capsular ligament of TMJ meeting the anterior incision, freeing the condyle and the discs shown in [Table/Fig-3] [30,31].

Step 8: The condyle and adjoining neck, including the Pterygoid fossa (fovea) was separated as a unit from the remainder of the mandible with an oscillating saw.

[Table/Fig-2]: Initial Incision made in the Preauricular skin fold.
[Table/Fig-3]: Articular disc and condyle removed en-bloc. (Images from left to right)

Boundaries of articular disc

Superiorly: The corresponding joint space and limitation by the glenoid fossa of the temporal bone.

Inferiorly: The mandibular condyle.

Anteriorly: The disc was continuous with the anterior capsular ligaments, superior and inferior lateral pterygoid muscle fibres.

Posteriorly: The disc was continuous with loose connective tissue.

Laterally and medially: Established upto the lateral and medial condylar poles.

Separation of disc from condyle [31]

Step 1: An incision was made horizontally through the bilaminar area just behind the posterior part of disc, thus opening the inferior compartment.

Step 2: It was continued to the lateral and medial poles, where the disc is most tightly adhered. The disc was then separated from the condylar poles and the incision was continued anteriorly.

Step 3: Here with sharp scalpel dissection, the anterior extension of the disc was separated from the condyle and the fibres of the lateral Pterygoid.

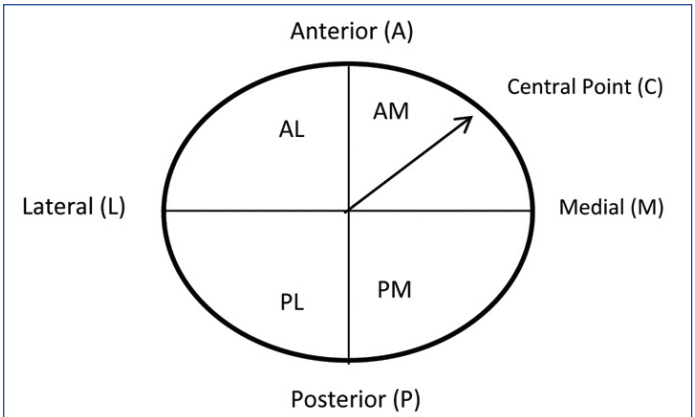
After that, certain morphometric parameters were decided as given in [Table/Fig-4] and also explained through diagrammatic representation as in [Table/Fig-5].

Sr. No.	Parameters
1.	Anterio-Posterior (AP)
2.	Medio-Lateral (ML)
3.	Central point
4.	Posterio-Medial (PM)
5.	Posterio-Lateral (PL)
6.	Anterio-Lateral (AL)
7.	Anterio-Medial (AM)

[Table/Fig-4]: Morphometric parameters.

Definitions of the morphometric parameters [32]

1. Anterior-Posterior (AP) Length: Defined as the maximum length drawn from the point A to point P of the articular disc.



[Table/Fig-5]: Diagrammatic representation of morphometric division of articular disc.

n1=Sample Size1

μ2=Mean2

σ2=Standard deviation2

n2=Sample size2

RESULTS

In present study, authors have collected data of total 10 cadavers bilaterally or 20 temporomandibular joints and articular disc and out of them 80.00% were male whereas 20.00% were female, in the age range of 55-65 years.

Circumference of the disc: The observed range of circumference of the disc in males was in the range of 67-75 mm while that in females was 68-70 mm. The mean average in males was in the range was 71-72 mm while that in females was 69 mm [Table/Fig-6].

Males						Females					
Left side			Right side			Left side			Right side		
OR	MA	SD	OR	MA	SD	OR	MA	SD	OR	MA	SD
67-75 mm	71 mm	2.73 mm	69-75 mm	72 mm	2.16 mm	68-70 mm	69 mm	1 mm	68-70 mm	69 mm	1 mm

[Table/Fig-6]: Circumference of the disc.
OR: Observed range; MA: Mean average; SD: Standard deviation

2. Medio-lateral (ML) length: Defined as the maximum length drawn from point M to point L of the articular disc.
3. After that we get a Point C of the disc or the Central point (C) region of the disc which is defined as the point obtained on dividing the disc into anterio-posterior and medio-lateral dimensions of the disc.
4. After that the disc was divided into four regions as Posterio-Medial (PM): defined as the part obtained by joining of the posterior, medial and central points of the disc.
5. Posterio-Lateral (PL): Defined as the part obtained by joining the posterior, lateral and central points of the disc.
6. Anterio-Lateral (AL): defined as the part obtained by joining the anterior, lateral and central points of the disc
7. Anterio-Medial (AM): Defined as the part obtained by joining the anterior, medial and central points of the disc.

After the appropriate division of the disc, the measuring of the disc was carried out by the primary investigator with the help of Aerospace Stainless Steel 8 inch/200 mm digital vernier calipers (manufacturer: Kovea Co., Ltd.,) for the thickness of the disc in all the five divisions namely PM, PL, AM, AL and central part of the disc. The examiner was calibrated based on the inter-examiner reliability method. The inter-examiner reliability score was 7 (interpreted as very good according to Regier et al.,). The dimensions (i.e., maximum length) in anterio-posterior and medio-lateral aspects and the circumference of the disc were measured with the help of a thread and standardised metallic scale. The perforations in the disc were evaluated on the basis of location, shape, size and number [33].

STATISTICAL ANALYSIS

Descriptive Statistically Method Applied: Two sample t-test Method. The software used for calculating is IBM Statistical Package for the Social Sciences (SPSS) Statistics.

Formula

Pooled Standard Deviation (r)=$\sqrt{\{(n1-1)\ \sigma12+(n2-1)\sigma22/(n1+n2-2)\}}$

Standard Error (S)=R×$\sqrt{(1/n1)+(1/n2)}$

T-Statistic=μ1-μ2/S

Where,

μ1=Mean1

σ1=Standard Deviation1

Thickness of the disc: The mean average thickness of the disc in the PM region in males was 1.4 mm on left side while on right side it was 1.5 mm. In females, it was 2.0 mm on both the sides. Similarly the mean average thickness of the disc in the PL region in males on left side was 1.5 mm and 1.6 mm on right side. While in females, it was 1.5 mm on both the sides.

The mean average thickness of the disc in the AL region of the disc in males on left side was 1.7 mm and 1.6 mm on right side while in females was 1.0 on left side and 1.5 mm on the right side. In the AM region it was 1.8 mm on the left side and 1.7 mm on the right side in males while that in females was 1.0 mm on both the sides. At the Central portion of the disc the thickness was in the range of 3.3-3.5 mm in both males and females on left and right side [Table/Fig-7].

Thickness of the disc							
1: Posterio-Medial region (PM)							
Males				**Females**			
Left side		Right side		Left side		Right side	
MA	SD	MA	SD	MA	SD	MA	SD
1.4 mm	0.5 mm	1.5 mm	0.5 mm	2.0 mm	0	2.0 mm	0
2: Posterio-Lateral region (PL)							
Males				**Females**			
Left side		Right side		Left side		Right side	
MA	SD	MA	SD	MA	SD	MA	SD
1.5 mm	0.5 mm	1.6 mm	0.7 mm	1.5 mm	0.7 mm	1.5 mm	0.7 mm
3: Anterio-Lateral region (AL)							
Males				**Females**			
Left side		Right side		Left side		Right side	
MA	SD	MA	SD	MA	SD	MA	SD
1.7 mm	0.4 mm	1.6 mm	0.5 mm	1.0 mm	0	1.5 mm	0.7 mm
4: Anterio-Medial (AM)							
Males				**Females**			
Left side		Right side		Left side		Right side	
MA	SD	MA	SD	MA	SD	MA	SD
1.8 mm	0.9 mm	1.7 mm	0.7 mm	1.0 mm	0	1.0 mm	0
5: Central Point of disc (C)							
Males				**Females**			
MA		SD		MA		SD	
3.3 mm		0.5 mm		3.5 mm		0.7 mm	

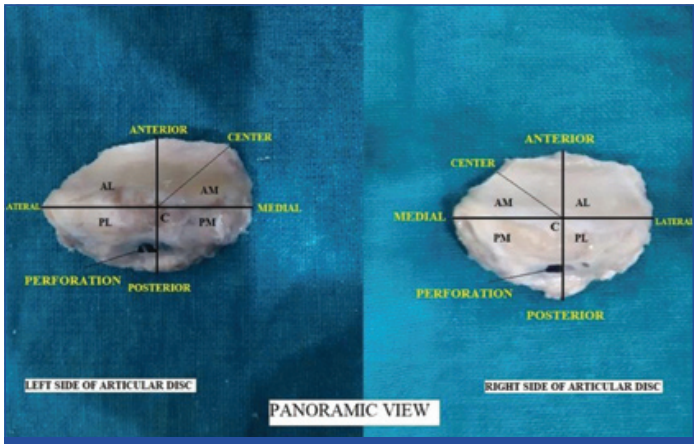
[Table/Fig-7]: Thickness of the disc.
MA: Mean Average; SD: Standard deviation

Dimensions of the disc: The mean average dimension of the disc in the Anterio-posterior direction in males was 12.875-13.75 mm while in females was 13.0-13.5 mm.The chi-square statistic is 0.0182. The p-value is 0.892757. The result is not significant at p-value <0.05. Similarly the Medio-lateral dimension in males was 22.0-23.62 mm while in females was 22-23 mm [Table/Fig-8].

Dimensions of the disc							
1: Anterio-Posterior (AP)							
Males				**Females**			
Left AP		Right AP		Left AP		Right AP	
MA	SD	MA	SD	MA	SD	MA	SD
12.875 mm	0.99 mm	13.75 mm	1.48 mm	13 mm	1.4 mm	13.5 mm	0.7 mm
2: Medio-Lateral (ML)							
Males				**Females**			
Left ML		Right ML		Left ML		Right ML	
MA	SD	MA	SD	MA	SD	MA	SD
22 mm	1.6 mm	23.62 mm	1.5 mm	23 mm	1.41 mm	22 mm	1.41 mm

[Table/Fig-8]: Dimensions of the disc.
MA: Mean Average; SD: Standard deviation

Perforations in the disc: In 1(10%) of the male, partially dentulous cadaver, aged about 57 years, perforation of disc was evident. On the left side the perforation is evident on the PL aspect and on the right side; perforation is evident on the PM aspect. The dimension of the perforation was 2.0×3.0 mm on the left side and 2.0×2.0 mm on the right side of the disc respectively. The shape of the perforation of the left is oval in shape while that on the right side is round in shape [Table/Fig-9].



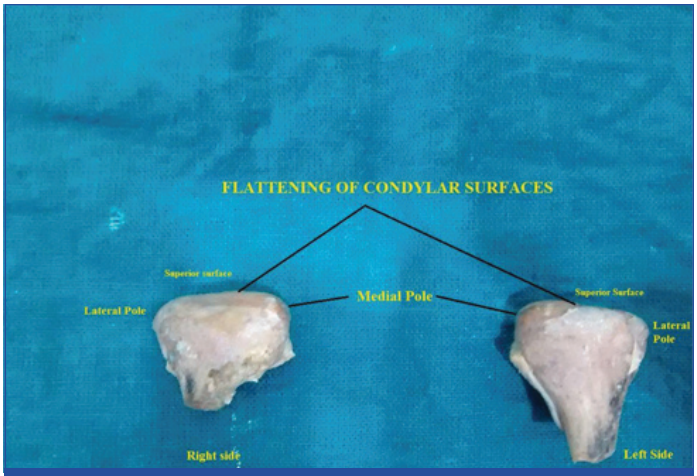
[Table/Fig-9]: Perforations in articular disc.

Irregular surfaces in the disc were observed in almost 16 temporomandibular joint discs and that too mostly in PM aspects. Flattening of the condylar surfaces was observed on the right and left side of another temporomandibular joint of same cadaver [Table/Fig-10].

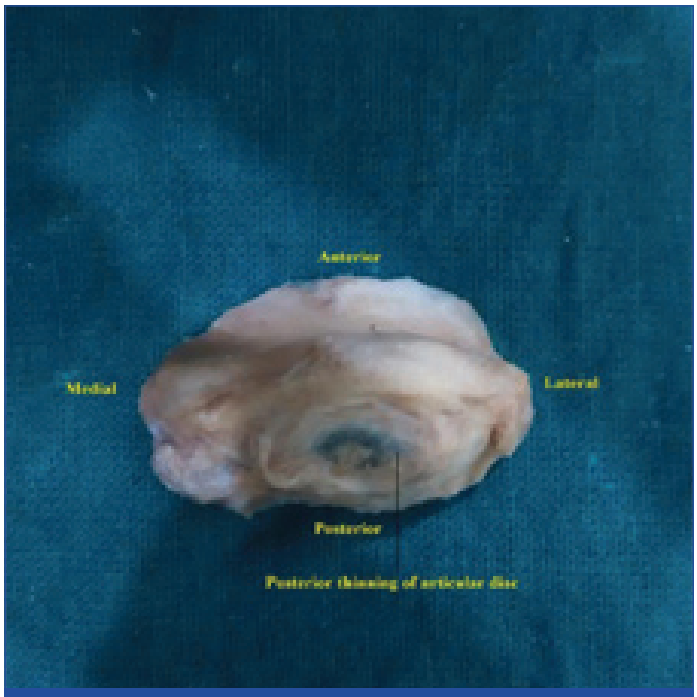
Posteriorly on the medial and lateral aspects, thinning of the disc was observed in the majority (90%) of non perforated discs, more often in partially dentulous males cadavers indicating a possible continuous activity leading to eventual thinning of the disc and which may lead to perforations in the near future [Table/Fig-11].

DISCUSSION

The temporomandibular joint in particular the Intra-articular disc has always been a focal point of clinical controversy, theory, research and surgery [34]. In the present study, it was observed that in males, there was reduction in the mean thickness of the articular disc in the posterior segment whether PM, PL right or left side which ranged from 1.5 mm-1.6 mm. Also, it was observed that in males the mean thickness of articular disc in the anterior segment whether AM; AL right or left side there was an increase in the thickness which ranged



[Table/Fig-10]: Flattening of the condylar surfaces.



[Table/Fig-11]: Posterior thinning of articular disc.

from 1.6-1.8 mm. This shows that the load transfer much have been much greater on the posterior aspect than that on the anterior aspect of the disc. Thus, the contact between the mandible and the cranium must have been concentrated, resulting in the damage on the posterior segment of the disc. This could have increased stress and strain on the posterior segment and could have led to thinning of the disc and eventually in perforation of the disc.

It was also observed that the mean of maximum length of articular disc in both males and females ranges from 12-13 mm in Anterio-posterior dimension and 22-23 mm in medio-lateral dimension. According to the present data, perforation of the disc most frequently occurred in the PM and PL part of the articular disc, and as per the available literature if the morphology of the disc is altered the discal ligaments get elongated and the disc slides or translates along the articular surface of the condyle. This type of movement is not present in the healthy joint. The degree of elongation is determined by the anatomy of the disc. Alteration in the morphology of the disc can change the normal functioning relationship.

In the resting closed joint position, the inter-articular pressure is low. The disc moves freely if the ligaments are elongated. In the closed joint position the disc will move into a more forward location, which will be resisited by the discal ligaments and posterior part of the disc [35]. Due to more pulling of the muscle, the posterior border of disc becomes more thinned and so the disc is displaced in more anterio-medial direction [36].

The superior retrodiscal lamina provides little resistance in the closed joint position; the medial and anterior positions of the disc are maintained. As the posterior border of the disc becomes thinned, it can be displaced further into the discal space so that the condyle becomes positioned on the posterior border of the disc. This condition is known as 'functional disc displacement' [37,38].

Irregular surfaces were also observed. Remodelling of the disc has usually been associated with thinning, whereas perforation has been considered a sign of degenerative change [39].

Another important fact that was observed in the present study was the shape of the condyle. Flat type of condylar surface was seen in the right and left side of the same individual having perforations in the disc. Flat type of condylar surfaces usually indicates the abnormal anatomic variation in the morphology of the condyle which can lead to erosion of the condylar surfaces eventually resulting into temporomandibular joint osteoarthritis.

In this present study, predisposing symptoms that could lead to temporomandibular joint disorders and internal derangement like thinning of the disc, perforation of the disc, irregular surfaces on the posterior aspect of the disc have been reported and this anatomical variation have been observed in the elderly people. Due to lack of dentition stress and strain gets increased on a particular segment of the disc resulting in thinning of the disc over a gradual period of time eventually resulting in perforation of the disc, if not been given timely treatment. As per the available literature [39] the signs and symptoms of arthrosis which include degenerative changes in the articular surfaces and perforations of the disc are usually seen in the elderly age group people than the younger group. Perforations are in a more advanced stage in the older group. Not only the frequency of degenerative changes but also their severity increases with age.

From the above discussed observations, its clinical implications and along with the literature that is being available [39], it can be suggested that the data which authors observed from the present study was more in relevance to the signs and symptoms of temporomandibular joint dysfunction and internal derangement that could have been already established or would probably be seen in the near future.

To prevent such type of temporomandibular joint dysfunction and internal derangement clinician should always look for the early signs and symptoms of it and should educate, motivate and explain the severity and consequences of such disorders to the patient so that their treatment could be initiated at an early stage for the betterment of the patient. Much literature has outlined the anatomy of the disc in relation to its thickness and maximum length of the disc in anterio-posterior and medio-lateral dimension [40]. This is the first kind of study that has also focused on the circumference of the disc. By knowing the circumference of the disc, the anatomy of the disc becomes more accurate and one can fabricate a prosthetic articular disc in a more precise way for the betterment of the patient.

Limitation(s)

The cadavers available in the Department of Anatomy were in the range of 55 to 65 years; hence all the age group populations cannot be covered. Due to unavailability of the female cadavers, equal amount of male and female cadavers could not be analysed. The study does not include completely edentulous cadavers which could have shown more anatomical variations in the disc due to prolonged forces deviated towards the articular disc and condylar surfaces. Cone-Beam Computed Tomography Systems (CBCT), 3D CT scan or an MRI could have been used to compare the results with the physical measurements of the disc which could have gained more precise morphometric anatomic measurements of the disc.

CONCLUSION(S)

From the present study, it can be concluded that excessive stress on a particular portion of the disc leads to thinning of the disc and ultimately leading to perforation in that area. A newer morphometric dimension that is the circumference of the articular disc was measured. By knowing the circumference of the articular disc replica of the articular disc can be accurately developed which is biocompatible to the human beings and surgeries like total articular disc replacement can be carried out with much ease which would be similar to knee arthroplasty procedures.

In conclusion, the study gives a greater knowledge about the complete morphometric anatomy of the articular disc that will guide maxillofacial surgeons and other research workers in accurately knowing the morphometric dimensions of the articular disc of temporomandibular joints so that they can replicate exact prosthetic articular disc. By addressing to the problems of temporomandibular joint at an early stage and diagnosing the abnormality of the temporomandibular joint the clinician can educate, motivate and cure the patient who requires surgical intervention in relation to the replacement of the articular disc by knowing the appropriate morphometric anatomy of the articular disc.

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PARTICULARS OF CONTRIBUTORS:
1. Postgraduate Student, Department of Oral and Maxillofacial Surgery, K. M. Shah Dental College and Hospital, Vadodara, Gujarat, India.
2. Head, Department of Oral and Maxillofacial Surgery, K.M. Shah Dental College and Hospital, Vadodara, Gujarat, India.
3. Head, Department of Anatomy, S.B.K.S Medical Institute and Research Centre, Vadodara, Gujarat, India.
4. Postgraduate Student, Department of Oral and Maxillofacial Surgery, K. M. Shah Dental College and Hospital, Vadodara, Gujarat, India.
5. Senior Lecturer, Department of Oral and Maxillofacial Surgery, K.M. Shah Dental College and Hospital, Vadodara, Gujarat, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:
Dr. Navin S Shah,
B-101, Prakruti Annexe, Jain Nagar, Paldi, Ahmedabad-380007, Gujarat, India.
E-mail: drnavin33@yahoo.com

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