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Cervical disc dimensions of the Thai population

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Problem : *The incidence of complications in cervical disc arthroplasty was 6.2% per treat level. Perioperative kyphosis, heterotopic ossification and migration may occur be due to undersized prosthesis. Measurement of the dimensions of cervical discs of the Thai population was aimed to be a pilot study to know the estimation of the dimensions of cervical discs that could be referred to the size of disc prosthesis devices.*

Objective : *To provide data regarding the diamension of cervical discs dimensions that can be used in Thailand for preoperative planning and design of cervical disc prosthesis in Thailand.*

Study design : *Descriptive study.*

Setting : *Department of Orthopedics, King Chulalongkorn Memorial Hospital.*

Method and Material : *From January 2008 to December 2008, 60 consecutive C-spine magnetic resonance imaging studies were performed on Thai subjects. MRI was performed using a 1.5 Tesla whole body MR imaging system with an extremity coil. Pulse sequences were T2-weighted images. The direction of the axial slice imaging placed the slice perpendicular to the spinal mechanical axis in the coronal plane and perpendicular to the long axis of the spine in the sagittal plane. All 60 images were reconstructed at 3-mm intervals.*

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Result : *Total mean maximum disc height in Thai population are as follows: C3-4 6.44 mm, C4 - 5 5.90 mm, C5 - 6 5.79 mm, C6 - 7 6.28 mm and C7 - T1 6.21 mm. The differences in the maximum disc heights between males and females were significant. The maximum and minimum distances from all samples are 6.63 mm and 5.47 mm, respectively. The total mean sagittal diameter in the Thai population are: C3i 14.77 mm, C4s 14.77 mm, C4i 15.23 mm, C5s 15.13 mm, C5i 15.74 mm, C6s 15.62 mm, C6i 15.72 mm, C7s 15.69 mm, C7i 15.79 mm and T1s 16.00 mm. The maximum and minimum distances from all samples are 16.47 mm and 13.33 mm respectively. The differences in maximum disc height between males and females were significant. The total mean transverse diameters in the Thai population are C3i 21.77 mm, C4s 22.15 mm, C4i 22.15 mm, C5s 22.95 mm, C5i 23.44 mm, C6s 24.23 mm, C6i 25.36 mm, C7s 26.28 mm, C7i 26.92 mm and T1s 26.95 mm. The maximum and minimum distances from all samples are 27.73 mm and 20.80 mm respectively. The differences in the maximum disc height between males and females were significant.*

Conclusion : *Measurement of disc dimensions can refer to the ranges of size to manufacturers for the devices to cover the use in Thai patients. The data fulfill the goal described for cervical disc dimension for the Thai population. The results of the project could provide design and data for the manufacturers and next step of experiment for cervical disc prosthesis suitable for the Thai population.*

Keywords : *Cervical disc dimensions, Cervical spondylosis, Cervical disc prosthesis.*

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อรรถพล วันดี, พิบูลย์ อิทธิระวิวงศ์, ทวีชัย เตชะพงศ์วรชัย, ไพรัช ตั้งพรประเสริฐ. มิติรูปร่างหมอนรองกระดูกของคนไทย. จุฬาลงกรณ์เวชสาร 2553 พ.ค. – มิ.ย.; 54(3): 225 – 36

เหตุผลการทำวิจัย : *การใช้หมอนรองกระดูกเทียมจากต่างประเทศหากมีขนาดไม่เหมาะสมกับกายวิภาคของคนไทย อาจทำให้เกิดปัญหา subsidence และ migration ได้*

วัตถุประสงค์ : *เพื่อเป็นข้อมูลมิติรูปร่างหมอนรองกระดูกของคนไทย เพื่อการวางแผนก่อนการผ่าตัดและเป็นข้อมูลเบื้องต้นในการออกแบบหมอนรองกระดูกเทียมในคนไทยต่อไป*

รูปแบบการทำวิจัย : *การศึกษาเชิงพรรณนา*

สถานที่ทำการวิจัย : *ฝ่ายศัลยกรรมกระดูก โรงพยาบาลจุฬาลงกรณ์*

วิธีการศึกษา : *คนไทยที่มาทำการตรวจคลื่นแม่เหล็กไฟฟ้าที่ระดับคอในช่วงเดือน ม.ค. ถึงเดือน ธ.ค. พ.ศ. 2551 จากการถ่ายภาพด้วยคอมพิวเตอร์สนามแม่เหล็กใช้ภาพ T2-weight images เป็นภาพตัดตั้งฉากกับแนวแกน mechanical axis ของกระดูกสันหลังในระนาบ coronal และตั้งฉากแนวตามยาวของกระดูกสันหลังในระนาบ sagittal ระยะห่างระหว่างภาพตัดห่างกัน 3 มม.ทั้งหมด 60 ภาพ*

ผลการศึกษา : *ผลของการวัดระยะคือค่าเฉลี่ยความสูงของหมอนรองกระดูกในคนไทย ค่าเฉลี่ยรวมทั้งหมดเป็นดังนี้ C3-4 6.44 mm, C4-5 5.90 mm, C5-6 5.79 mm, C6-7 6.28 mm และ C7-T1 6.21 mm. มีความแตกต่างระหว่างระยะในเพศชายและเพศหญิงอย่างมีนัยสำคัญ ค่าความสูงที่สุดและต่ำที่สุดจาก sample ทั้งหมดคือ 6.63 mm และ 5.47 mm ตามลำดับ ส่วนค่าเฉลี่ยความกว้างในแนวกลางของหมอนรองกระดูกในคนไทยค่าเฉลี่ยรวมทั้งหมดเป็นดังนี้ $C3_i$ 14.77 mm, $C4_s$ 14.77 mm, $C4_i$ 15.23 mm, $C5_s$ 15.13 mm, $C5_i$ 15.74 mm, $C6_s$ 15.62 mm, $C6_i$ 15.72 mm,$C7_s$ 15.69 mm, $C7_i$ 15.79 mm และ $T1_s$ 16.00 mm. มีความแตกต่างระหว่างระยะในเพศชายและเพศหญิงอย่างมีนัยสำคัญ ค่าความสูงที่สุดและต่ำที่สุดจาก sample ทั้งหมดคือ 16.47 mm และ 13.33 mm ตามลำดับ ส่วนค่าเฉลี่ยความกว้างในแนวขวางของหมอนรองกระดูกในคนไทยค่าเฉลี่ยรวมทั้งหมดเป็นดังนี้ $C3_i$ 21.77 mm, $C4_s$ 22.15 mm, $C4_i$ 22.15 mm, $C5_s$ 22.95 mm, $C5_i$ 23.44 mm, $C6_s$ 24.23 mm, $C6_i$ 25.36 mm,$C7_s$ 26.28 mm, $C7_i$ 26.92 mm และ $T1_s$ 26.95 mm. มีความแตกต่างระหว่างระยะในเพศชายและเพศหญิงอย่างมีนัยสำคัญ ค่าความสูงที่สุดและต่ำที่สุดจาก sample ทั้งหมดคือ 27.73 mm และ 20.80 mm ตามลำดับ*

สรุป : *มิติรูปร่างหมอนรองกระดูกสันหลังที่วัดได้ทำให้รู้กรอบคร่าว ๆ ของขนาดอุปกรณ์ในการวางแผนการรักษาและทำการผลิตในกรณีจะผลิตออกใช้จริง*

คำสำคัญ : *มิติรูปร่างหมอนรองกระดูก, กระดูกคอเสื่อม, การใส่อวัยวะเทียม.*

Symptoms suggestive of cervical and lumbar stenosis are relatively common among this cohort of older men, and generalized spinal stenosis may occur in as many as 4%.[1] The most common age group of the Thai population that needs the prothesis is 30 - 60 years.[2]

Anterior cervical discectomy and fusion (ACDF) of one or two levels for spondylotic myelopathy or radiculopathy has been proved to be an extremely effective procedure in terms of clinical and radiographic outcomes. [3-5] The rate of adjacent segment degeneration has been reported to be as high as 3% to 11% per year for the first decade after fusion, with up to two- thirds of patients who required reoperation. [6,7] Hypermobility of segments adjacent to a fused segment is also often observed.[8] Advantages of cervical disc arthroplasty over anterior cervical discectomy and fusion.[9] Recently, cervical arthroplasty trends to be used more than ACDF. The incidences of complications in cervical disc arthroplasty were 6.2% per treat level.[10] The complications were, namely:

1. retropharyngeal hematoma;
2. neurological worsening;
3. intraoperative and delay migration;
4. postoperative segmental kyphosis;
5. heterotopic ossification and spontaneous fusion;
6. partial dislocation of the prosthesis in extension; and,
7. neck-and-shoulder pain

Some complications from arthroplasty such as subsidence may be occurred after prosthesis replacements. [11] There are 3 factors that were had been studied in cervical cage.[11]

1. Distance from anterior vertebral rim;
2. Spacer versus end-plate surface ratio;
3. Ratio of pre- and immediate postoperative height of the inter-vertebral space.

Perioperative kyphosis may occur after removing the anchoring pin and dual-track milling guide because of the mismatch of the size of the prosthesis.[10] Heterotopic ossification may occur because of limited motion of the prosthesis due to undersized prosthesis.[10] Delayed prosthesis migration was found in patients who had immediate kyphosis after operation.[10] In a 2 - year follow up period, a re-oparative of 2.05% appears to be acceptable rate considering the investigative nature of this study.[12]

However, clinical study is still in need regarding the incomplete knowledge of the dimensions of cervical discs of the Thai population.[13] We, therefore, conducted a study of the dimensions cervical discs of the Thai population to prepare the data for preoperative planning and designs of cervical disc prostheses.

Materials and Methods

Patients Selection

From January 2008 to December 2008, 60 consecutive C-spine magnetic resonance imaging studies were performed in Thai subjects. The inclusion criteria of each subjects were: the subjects is between 22 to 76 years of age, having no congenital deformity, scoliosis, traumatic injury to the spine and/or having no previous spine surgery. From the criteria, 30 were males and 30 females were recruited. The demographic data are shown in Table 1.

Table 1. The basic information of the subjects*

Sex	Total	Male	Female
Subjects (Number)	60	30	30
Age (year)	51.00 ± 12 (22 - 76)	52.47 ± 11.01 (30 - 72)	50.33 ± 13.13 (22 - 76)
Weight (Kg.)	60.75 ± 11.80 (40 - 100)	66.90 ± 10.00 (50 - 100)	54.60 ± 10.24 (40 - 88)

*Represented as mean ± standard deviation, median (range)

MRI measurements

MRI was performed using a 1.5 Tesla whole body MR imaging system (Siemens 1.5 Tesla, Avanto, Germany) with an extremity coil. Pulse sequences were T2-weighted images.

The direction of the axial slice imaging placed the slice perpendicular to the spinal mechanical axis in the coronal plane and perpendicular to the long axis of the spine in the sagittal plane.

All 60 images were reconstructed at 3-mm intervals. These images were obtained from patients who attended clinics for neck pain. Patients below the age of 20, those with congenital cervical spine anomaly, having history of past surgery of the cervical spine, pregnancy, and/or any abnormal disc, which was outside the Woodend Classification I (Figure 1.), were all excluded. The Woodend Classification grades of the disc on a scale of 1- 4, where grade 1 is normal disc with a white nucleus, normal shape, and no annular tears.[14]

Measurement of the disc dimensions counted on 3-plane slice imaging at the most midline cut of MRI in T2 weighted image. Considering lordosis of the cervical spine, we measure the height of vertebral body at anteriorly, posteriorly, and maximum disc height. The data concerning the endplates were obtained from the caudal surfaces. On each surface we measured three diameters; the median sagittal diameter (SD) which goes through the middle of the transverse diameter; the transverse diameter (TD) which is the maximum breadth across the vertebral body; the "diagonal diameter" (DD) which we considered the longest diameter running through the intersection of the two others and forming and angle between 30° and 60° with the sagittal plane. If we suspected a slight asymmetry, we would compared the diameter from the right anterior to the left posterior with the one from the left anterior in the right posterior. However, we never found any significant difference. Grossly asymmetrical cases would have been considered pathological and therefore exclude. The data were obtained by a computerized coordinate system from MRI images. All data were analyzed by Student's t test, ANOVA, and correlation between levels was analyzed. The validation of the data was done by intra-observer method and analyzed by Student pair t-test. A total of 300 measured cervical spine levels were done.

Results and Discussion

Disc dimensions

Measurement was done in 60 samples (30 males; 30 females) and the results are shown as table 3.

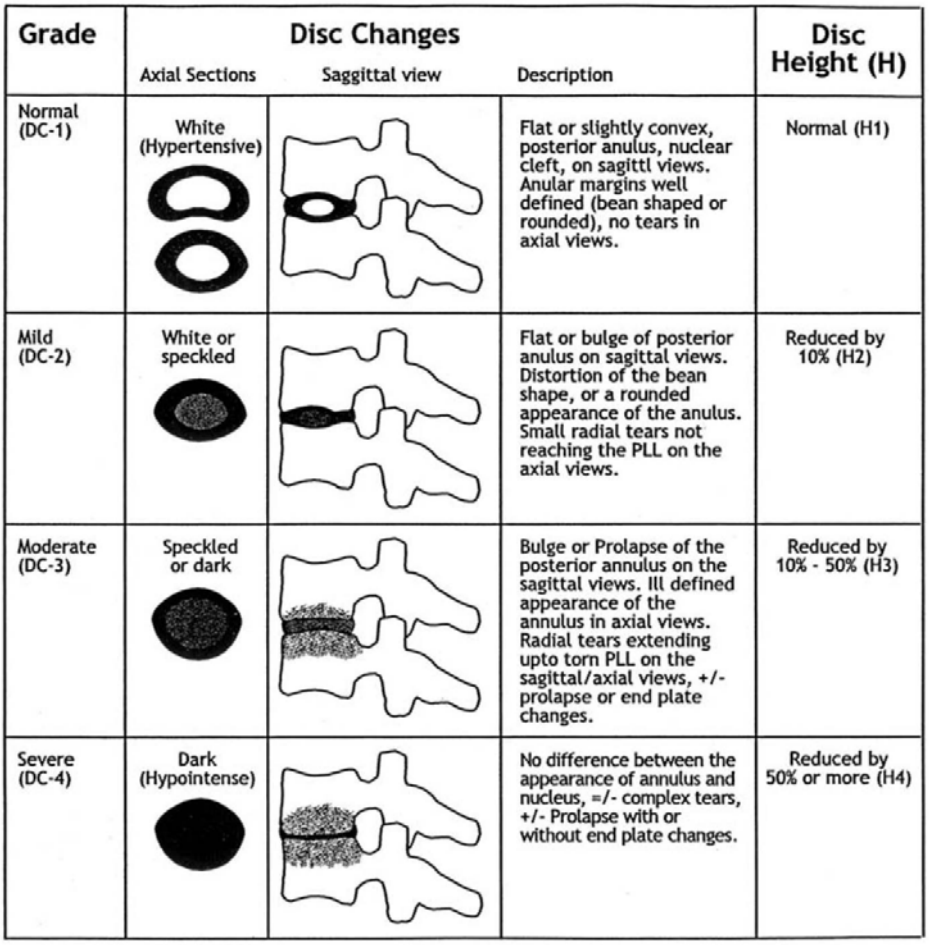

Figure 1. Woodend Classification.

Table 2. Average anterior cervical disc height.

Subject	Subject number	Average anterior cervical disc height (mm)				
		C3-4	C4-5	C5-6	C6-7	C7-T1
Male	30	3.40	3.40	3.17	3.50	3.63
Female	30	3.03	2.77	2.47	3.03	2.93
Total	60	3.41	3.23	3.05	3.44	3.51

Table 3. Maximum cervical disc heights.

Subject	Subject number	Average maximum cervical disc height (mm)				
		C3-4	C4-5	C5-6	C6-7	C7-T1
Male	30	6.63	6.07	5.87	6.37	6.20
Female	30	5.83	5.53	5.47	5.87	6.10
Total	60	6.44	5.90	5.79	6.28	6.21

The maximum anterior cervical disc height in the male subjects was 3.63 mm at C3 - 4 level and minimum 2.47 mm at C5-6 level in the female subjects. There is statistical significantly difference between the male and the female subjects with was attested by ANOVA. (P-value <0.05). The mean difference is shown to be between male and female. Considering lordosis of the cervical spine, we measured the height of the vertebral body at anteriorly, posteriorly, and maximum disc height. The results are shown as table 3.

Maximum cervical disc height in the male subjects was 6.63 mm at C3-4 level and minimum 5.47 mm at C5-6 level in the female. There are statistical significantly differences between those of men and women attested by ANOVA (P-value <0.05) Regarding the lordosis of the cervical spine, we measured the heights of the vertebral body at anteriorly, posteriorly, and the maximum disc height. The results are shown as table 4.

The maximum posterior cervical disc height in the male subjects was 3.30 mm at C3-4 level and the minimum of 2.37 mm at C5-6 level in the female. There are statistical significantly difference between men and women, attested by ANOVA (P-value <0.05). Regarding lordosis of the cervical spine, we measured the height of the vertebral body at anteriorly, posteriorly, and the maximum disc height. The results are shown as table 5.

The maximum sagittal diameter in the male subject was 16.47 mm at T1 level and the minimum of 13.33 mm at $C3_i$ level in the female. There are statistical significantly differences between men and women, attested by ANOVA. (P-value <0.05). The results are shown as table 6.

Table 4. Posterior cervical disc heights.

Subject	Subject number	Average posterior cervical disc height (mm)				
		C3-4	C4-5	C5-6	C6-7	C7-T1
Male	30	3.30	2.97	2.97	3.03	3.03
Female	30	2.80	2.63	2.37	2.53	2.67
Total	60	3.23	2.87	2.90	3.00	2.95

Table 5. Sagittal diameters.

Subject	Subject number	Average sagittal diameters (mm)									
		$C3_i$	$C4_s$	$C4_i$	$C5_s$	$C5_i$	$C6_s$	$C6_i$	$C7_s$	$C7_i$	$T1_s$
Male	30	15.17	15.1	15.67	15.63	16.17	15.9	16.2	16.07	16.33	16.47
Female	30	13.33	13.37	13.77	13.37	13.93	13.97	14.03	14.13	13.67	14.22
Total	60	14.77	14.77	15.23	15.13	15.74	15.62	15.72	15.69	15.79	16

Table 6. Transverse diameters.

Subject	Subject number	Average transverse diameters (mm)									
		$C3_i$	$C4_s$	$C4_i$	$C5_s$	$C5_i$	$C6_s$	$C6_i$	$C7_s$	$C7_i$	$T1_s$
Male	30	22.1	22.3	22.4	23.2	23.73	24.57	25.83	26.6	27.47	27.73
Female	30	20.8	21.5	21.7	22.2	22.83	23.4	24.13	25.43	25.57	24.8
Total	39	21.77	22.15	22.15	22.95	23.44	24.23	25.36	26.28	26.92	26.95

The maximum transverse diameter in the male subjects was 27.73 mm at T1 level and the minimum of 20.80 mm at $C3_i$ level in female. There are statistical significantly difference between men and women, attested by ANOVA. (P-value <0.05). The results are shown as table 7.

The maximum diagonal diameter in the male subjects was 25.57 mm at $C7_s$ level and the minimum of 21.37 mm at $C3_i$ level in female. There are statistical significantly difference between men and women with test by ANOVA. (P-value <0.05)

The validation of data has been done by intraobserver method and analyzed by Student pair t-test. The results are shown as table 8.

From previous study of cervical disc dimension[15] (as table 2), we compared cervical dics dimensions data between sagittal diameter, trasnverse diameter, and diagonal diameter by using Student's t-test. The results are shown as table 9

Table 7. Diagonal diameters.

Subject	Subject number	Average diagonal diameters (mm)									
		$C3_i$	$C4_s$	$C4_i$	$C5_s$	$C5_i$	$C6_s$	$C6_i$	$C7_s$	$C7_i$	$T1_s$
Male	30	21.9	22.73	22	23.13	23.2	23.93	24.83	25.57	25.13	25.53
Female	30	21.37	22.4	21.57	22.47	23.3	23.17	23.83	24.5	24.43	23.8
Total	60	21.63	22.57	21.78	22.8	22.75	23.55	24.33	25.03	24.78	24.67

Table 8. Validation of intraobserver measurement.

Subject	Mean of 1st measurement (mm)	Mean 2nd measurement (mm)	P-value
Sagittal diameter	14.47	14.46	0.1
Transverse diameter	25.52	25.14	0.2
Diagonal diameter	22.49	21.73	0.00001
Disc height	5.79	5.95	0.08

Table 9. Compare previous study.

Subject	Previous study S. Aharinejad et al.	Cervical disc dimensions	P-value
Transverse diameter (mm)	21.2 ± 3.7	23.1 ± 3.6	<0.001
Diagonal diameter (mm)	19.6 ± 3.0	23.4 ± 2.3	<0.001
Sagittal diameter (mm)	16.2 ± 2.1	14.8 ± 1.9	<0.001

The cervical disc dimensions of Thai population is different from previous study that the sample data were collected from Austria (caucasian). This different dimensions of the cervical dics from caucasion may be inappropriated cervical dics prosthesis that be used in Thailand.

Conclusion

This project aimed to know the cervical disc dimensions of Thai population and to compare with cervical disc prosthesis that be used in Thailand. As the cervical disc dimensions to use in cervical spine measurement of the cervical disc dimensions was done only in cervical segment. From the measurement result, it was recommended that the cervical disc prosthesis should cover 7 varies sizes (from 3 mm to 9 mm) for disc height, 6 sizes (from 10 mm to 20.50 mm) for sagittal diameter, and 8 sizes (from 17 mm to 31.20 mm) for transverse diameter.

The cervical disc dimensions in this research had been measured by MRI method that it could replace disc morphology in early degenerative motion segment and correct it to near normal. It allowed motion segment to move in flexion and extension.

There are different demographic data between male and female, may be limited to compare between male and female. More size disc may be available in Thailand. To compare the cervical disc dimension with previous study was significantly different in sagittal diameter, transverse diameter, and diagonal diameter. The differences have been shown that cervical disc dimensions of Thai population seem to be smaller in disc height and transverse diameter than previous study.

Some complications from arthroplasty such as subsidence and migration may be occurred after prosthesis replacements.[11] Although, Failure of an intact cervical endplate occurs with an axial load of 634-745 N.[16,17] The cervical disc prosthesis subsidence likely stem from multiple causes including osteoporosis, aggressive endplate preparation, postoperative exogenous forces, and bracing.[4, 18]The improperly prosthesis disc height, the compressive force increase higher when increasing disc height.[19]

If we have a proper size of disc dimension, it may decrease incidence of subsidence or migration. The results of cervical disc dimensions may be useful for preoperative planning and data for cervical disc prosthesis design in the future.

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