



A STUDY OF MORPHOMETRIC AND POSITIONAL ASYMMETRY OF OCCIPITAL CONDYLES ON DRY HUMAN SKULLS.

Anatomy

Dr Manoj E Borkute*

Associate Professor *Corresponding Author

Dr K Shyamkishore

Professor & HOD

Dr Pritha S Bhuiyan

Professor & HOD Retired

ABSTRACT

Occipital condyles represent the cranial portion of the cranio-cervical junction. Axial lengths of the right and the left occipital condyles are of great dimensional importance in cases of transcondylar surgical approaches. Study was done on 105 dry adult human skulls. Linear measurements were carried out on 100 skulls from two teaching hospitals in Maharashtra. Purpose of study was to find morphometric asymmetry between right and left occipital condyles. Another important aspect of the study was to find positional asymmetry between right and left occipital condyles with respect to foramen magnum. This study will be helpful in analyzing different approaches to skull base surgery.

KEYWORDS

Occipital condyles, Morphometric asymmetry Positional asymmetry Transcondylar surgical approaches.

INTRODUCTION

Each occipital condyle is oval in outline and is oriented obliquely so that its anterior end lies nearer the midline. It is markedly convex anteroposteriorly, less so transversely, and its medial aspect is roughened by ligamentous attachment. Basion is the middle point of anterior margin of foramen magnum.² Opisthion is middle point of posterior margin of foramen magnum.³

The occipital condyles represent the cranial portion of the craniocervical junction and they form the articular surface of the atlas so that the axial lengths of the right and the left occipital condyles and the anterior intercondylar distance are of great dimensional importance, especially during the exposure of the vertebral artery and the resection of the occipital condyles, as in cases of transcondylar surgical approaches to reach the lesions at the ventrolateral clivus and jugular foramen.⁴ During last two decades, craniocervical junction has been focus of variety of anatomical and biomechanical studies. Most of these studies focus on morphometric analysis of occipital condyles. Some provide information based on the different surgical procedures. Newly described transcondylar approach requires information regarding the morphometric aspects of the occipital condyle.⁵ However there are very few studies pertaining to occipital condyles and foramen magnum in Indian subjects. This study was undertaken with following aims and objectives

- To analyze occipital condyles morphometrically
- To find morphometric asymmetry between right and left occipital condyles
- To find positional asymmetry between right and left occipital condyles with respect to foramen magnum

MATERIAL & METHODS

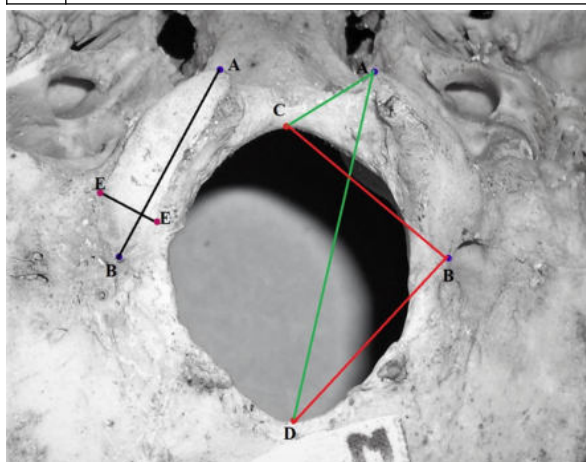
Material for this study consisted of 105 dry adult human skulls. Linear measurements were carried out on 100 skulls. Separate measurements were done for some skulls showing variations. Material was obtained from two teaching hospitals in the state of Maharashtra (45 skulls from one and 60 from other). All measurements were recorded to the nearest millimeter with the help of a divider and scale calibrated in millimeters. Measurements are based on following bony landmarks on the skull:

- Basion
- Opisthion
- Anterior tip of right occipital condyle
- Posterior tip of right occipital condyle
- Anterior tip of left occipital condyle
- Posterior tip of left occipital condyle

This study was carried out between 2006-09 as a part of thesis work. It was submitted to MUHS (Maharashtra University of Health sciences) in 2009.

Serial No.	Parameters
------------	------------

1	The length of right occipital condyle
2	The width of right occipital condyle
3	Distance between the posterior tip of right occipital condyle and opisthion
4	Distance between the anterior tip of right occipital condyle and opisthion
5	Distance between the posterior tip of right occipital condyle and basion
6	Distance between the anterior tip of right occipital condyle and basion
7	The length of left occipital condyle
8	The width of left occipital condyle
9	Distance between the posterior tip of left occipital condyle and opisthion
10	Distance between the anterior tip of left occipital condyle and opisthion
11	Distance between the posterior tip of left occipital condyle and basion
12	Distance between the anterior tip of left occipital condyle and basion



A-B: The length of occipital condyle

E-E: The width of occipital condyle

C-A: Distance between the anterior tip of occipital condyle and basion

C-B: Distance between the posterior tip of occipital condyle and basion

D-A: Distance between the anterior tip of occipital condyle and opisthion

D-B: Distance between the posterior tip of occipital condyle and opisthion

RESULT

Nothing is known about antecedents regarding, community, caste, social status etc, of specimens. Owing to the difficulty in accurate sexing of skull no such attempt was made. It is not unlikely that significant proportion of female skulls may have been included in this study. Skulls showing gross asymmetry or deformity were rejected as unsuitable.

Measurements of 100 skulls recorded and analysed. Because of presence of variations, measurements from 5 skulls were excluded from study. Result obtained are as follows.

SN	PARAMETER	Range (in mm)	Mean (in mm)	Standard Deviation
1	The length of ROC	16-29	22.7	2.294
2	The width of ROC	9-17	12.6	1.482
3	Distance between the posterior tip of ROC and opisthion	21-35	28.0	2.353
4	Distance between the anterior tip of ROC and opisthion	31-45	38.8	2.249
5	Distance between the posterior tip of ROC and basion	21-34	26.7	2.005
6	Distance between the anterior tip of ROC and basion	8-15	11.5	1.283
7	The length of LOC	16-31	22.4	2.454
8	The width of LOC	10-17	13.1	1.490
9	Distance between the posterior tip of LOC and opisthion	22-35	28.5	2.307
10	Distance between the anterior tip of LOC and opisthion	29-47	38.9	3.366
11	Distance between the posterior tip of LOC and basion	22-38	27.3	2.364
12	Distance between the anterior tip of LOC and basion	9-17	12.6	1.385

Abbreviations – ROC(Right Occipital Condyle) AND LOC (Left Occipital Condyle)

Morphometric Asymmetry**1. Comparison Between Condylar Lengths**

Parameter	Number	Range (in mm)	Mean (in mm)	Standard Deviation
Right occipital condyle length	100	16-29	22.7	2.294
Left occipital condyle length	100	16-31	22.4	2.454

Paired T- Test Result For Condylar Length

Paired Differences					t	df	p
Mean	Standard Deviation	Standard Error of Mean	95% Confidence Interval of Difference				
			upper	lower			
0.290	1.616	0.162	0.031	0.611	1.794	99	0.076

It is found that mean length of right occipital condyle in 100 skull is 22.7mm, range being 16-29mm with standard deviation of 2.294 and Mean length of left occipital condyle in 100 skulls is 22.4mm, range being 16 to 31mm with standard deviation of 2.454. Correlation coefficient calculated by Pearson's method is 0.770, significant at the 0.01 level.

Paired t-test shows that mean difference between length of right and left occipital condyle is 0.290, 95% confidence interval upper limit of which is 0.031 & lower limit is 0.611 and P-value is 0.076 which is greater than 0.05. Hence it shows that though right occipital condyle is slightly longer than left this difference is nonsignificant.

2. Comparison Between Condylar Widths.

Parameter	Number	Range (in mm)	Mean (in mm)	Standard Deviation
Right occipital condyle width	100	9-17	12.6	1.482
Left occipital condyle width	100	10-17	13.1	1.490

Paired T-test Result For Condylar Width

Paired Differences					t	df	p
Mean	Standard Deviation	Standard Error of Mean	95% Confidence Interval Of Difference				
			upper	lower			

0.490	1.275	0.128	0.743	0.237	3.843	99	0.000
-------	-------	-------	-------	-------	-------	----	-------

It is found that mean width of right occipital condyle in 100 skull is 12.6 mm., range being 9-17mm with standard deviation of 1.482 whereas mean width of left occipital condyle in 100 skulls is 13.1mm, range being 10 to 17mm with standard deviation of 1.490. Correlation coefficient calculated by Pearson's method is 0.641, significant at the 0.01 level.

Paired t-test shows that mean difference between width of right and left occipital condyle is 0.490, 95% confidence interval upper limit of which is 0.743 & lower limit is 0.237 and P-value is 0.000 which is less than 0.05. Hence it shows that though left occipital condyle is wider than right and difference is significant.

Positional Asymmetry**3. Comparison Of Distance Between The Posterior Tip Of Occipital Condyles And Opisthion. (fig. 8c)**

Parameter	Number	Range (in mm)	Mean (in mm)	Standard Deviation
Right	100	21-35	28.0	2.353
Left	100	22-35	28.5	2.307

Correlation coefficient calculated by Pearson's method is 0.657, significant at the 0.01.

Paired T-test Result

Paired Differences					t	df	p
Mean	Standard Deviation	Standard Error of Mean	95% Confidence Interval Of Difference				
			upper	lower			
0.510	1.931	0.193	0.893	0.127	2.642	99	0.010

It was found that mean distance between the posterior tip of occipital condyle and opisthion on the right side to be 28.0+2.353 mm, range being 21-35 mm whereas on the left side it was 28.5+2.307 mm, range being 22-35 mm.

Paired t-test shows that mean difference between the posterior tip of occipital condyle and opisthion on the right and left side is 0.510, 95% confidence interval upper limit of which is 0.893 & lower limit is 0.127 and P-value is 0.010 which is less than 0.05 and hence the difference is significant.

4. Comparison Of Distance Between The Anterior Tip Of Occipital Condyles And Opisthion.

Parameter	Number	Range (in mm)	Mean (in mm)	Standard Deviation
Right	100	31-45	38.8	2.846
Left	100	29-47	38.9	3.366

Correlation coefficient calculated by Pearson's method is 0.749, significant at the 0.01.

Paired T-test Result

Paired Differences					t	df	p
Mean	Standard Deviation	Standard Error of Mean	95% Confidence Interval Of Difference				
			upper	lower			
0.170	2.252	0.225	0.617	0.277	0.755	99	0.452

It is found that mean distance between the anterior tip of occipital condyle and opisthion on the right side is 38.8mm, range being 31-45mm with standard deviation of 2.846 whereas on the left side it is 38.9mm, range being 29-47mm with standard deviation of 3.366.

Paired t-test shows that mean difference between the anterior tip of occipital condyle and opisthion on the right and left side is 0.170, 95% confidence interval upper limit of which is 0.617 & lower limit is 0.277 and P-value is 0.452 which is greater than 0.05 and the difference is nonsignificant.

5. Comparison Of Distance Between The Posterior Tip Of Occipital Condyles And Basion.

Parameter	Number	Range (in mm)	Mean (in mm)	Standard Deviation
Right	100	21-34	26.7	2.005
Left	100	22-38	27.3	2.364

Correlation coefficient calculated by Pearson's method is 0.596, significant at the 0.01 level.

Paired T-test Result

Paired Differences				t	df	p	
Mean	Standard Deviation	Standard Error of Mean	95% Confidence Interval Of Difference				
			upper				lower
0.590	1.990	0.199	0.985	0.195	2.964	99	0.004

It is found that mean distance between the posterior tip of occipital condyle and basion on the right side 26.7mm, range being 21-34mm with standard deviation of 2.005 whereas on the left side it is 27.3mm, range being 22-38 mm with standard deviation of 2.364.

Paired t-test shows that mean difference between the posterior tip of occipital condyle and basion on the right and left side is 0.590, 95% confidence interval upper limit of which is 0.985 & lower limit is 0.195 and P-value is 0.004 which is less than 0.05 and hence the difference is significant.

6. Comparison Of Distance Between The Anterior Tip Of Occipital Condyles And Basion.

Parameter	Number	Range (in mm)	Mean (in mm)	Standard Deviation
Right	100	8-15	11.5	1.283
Left	100	9-17	12.6	1.385

Correlation coefficient calculated by Pearson's method is 0.571, significant at the 0.01 level.

Paired T-test Result

Paired Differences					t	df	p
Mean	Standard Deviation	Standard Error of Mean	95% Confidence Interval Of Difference				
			upper	lower			
1.140	1.239	0.124	1.386	0.894	9.199	99	0.000

It is found that mean distance between the anterior tip of occipital condyle and basion on the right side 11.5mm, range being 8-15mm with standard deviation of 1.283mm whereas on the left side it is 12.6mm, range being 9-17mm with standard deviation of 1.385.

Paired t-test shows that mean difference between the posterior tip of occipital condyle and opisthion on the right and left side is 1.140, 95% confidence interval upper limit of which is 1.386 & lower limit is 0.894 and P-value is 0.000 which is less than 0.05 and hence the difference is significant.

DISCUSSION

Morphometric Asymmetry

The length of occipital condyle is an important surgical issue. The anatomical and biomechanical results of partial condylectomy in a short type are different from the results obtained in a long type occipital condyle. The same amount of partial condylectomy may cause greater occipitocervical instability in short occipital condyle, whereas a long condyle may require a more extensive resection for optimum visualization. Similar surgical considerations may be correct for the occipital condyle width. Surgery in a wider condyle may be more demanding.⁵

Condylar Length

Comparison with previous results reported in literature.

	Naderi et al.	Cicekcibas et al.	Lang et al.	Muthukumar et al.	Kizilkana et al.	Wen et al.	Bozbuga et al.	Present study
Right	23.6	24.38	22.9	-	-	-	-	22.7
Left	23.2	24.00	22.9	-	-	-	-	22.4
combine	23.4	24.18	22.9	23.6	24.5	21	23.1	22.6

In a study done by Wen et al. mean length of occipital condyle was found to be 21.00mm.⁶ Bozbuga and colleagues estimated mean length of occipital condyle to be 23.1mm.⁷ Muthukumar et al. has given range of length of occipital condyle as 18 to 34mm with the mean being 23.6mm.⁸

Kizilkana et al. and colleagues studied the morphometry of hypoglossal canal, occipital condyle and foramen magnum on 59 dry skulls and has

given mean length of occipital condyle (right and left combine) 24.5+/-2.5mm. He also stated that there was no significant difference (P>0.05) in measurements taken from the right and left sides.⁹

Naderi et al. reported that the mean length of right occipital condyle 23.6mm with standard deviation of ± 2.5 mm, range being 16.7 to 30.6mm and mean length of left occipital condyle 23.2mm, with standard deviation of ± 2.4 mm, range being 16.2 to 30.6mm. He did not find significant bilateral difference in his study (p-value 0.710).⁵

In a study done by Cicekcibas et al. and colleagues axial length of occipital condyle on left side is 24.01 ± 2.31 and on the right side is 24.36 ± 2.32 with t-value of 1.942 and p-value of 0.059. A significant association was also found between the right and left axial lengths of occipital condyles ($r = 0.870$) ($P < 0.01$). They found non significant difference between the right and left axial lengths.¹⁰

Lang reported that the axial length of the occipital condyle on the right ranged from 15 to 27mm, with an average of 22.9mm, whereas on the left, it ranged from 15 to 29mm, with a mean value of 22.9mm. Lang also did not find significant bilateral difference in his study.¹¹

In the present study, mean length of occipital condyle on right side is 22.7 ± 2.294 with range of 16 to 29mm where as on the left side it is 22.4 ± 2.245 , range being 16 to 31. A significant association was found between the length of right and left occipital condyle as indicated by correlation coefficient calculated by Pearson's method ($r = 0.770$).

No significant bilateral difference was found between right and left occipital condyle lengths as shown by the result of paired t-test ($p = 0.770$ which is > 0.05). result agrees with the previous studies.

Condylar Width

Comparison With Previous Studies:

	Naderi et al.	Bozbuga et al.	Olivier et al.	Muthukumar et al.	Kizilkana et al.	Present study
Right	10.6	-	-	-	-	12.6
Left	10.6	-	-	-	-	13.1
Combine	10.6	11.3	11.5	14.7	13.1	12.7

Olivier G has given mean width of occipital condyle as 11.5mm with standard deviation of ± 1.2 mm.¹² Bozbuga and colleagues in their study estimated mean length of occipital condyle to be 11.3mm.⁷ Muthukumar et al. has given range of width of occipital condyle as 12 to 17mm with the mean being 14.7mm.⁸

Naderi et al. found that the mean width of right occipital condyle 10.6mm with standard deviation of ± 1.4 mm, range being 7 to 15.7mm and mean length of left occipital condyle 10.6mm, with standard deviation of ± 1.4 mm, range being 6.5 to 15.8mm. He did not find significant bilateral difference in their study (p-value 0.967).⁵

Kizilkana et al. and colleagues studied the morphometry of hypoglossal canal, occipital condyle and foramen magnum on 59 dry skulls and has given mean width of occipital condyle (right and left combine) 13.1 ± 1.6 mm. He also stated that there was no significant difference ($P > 0.05$) in measurements taken from the right and left sides.⁹

In the present study, mean width of occipital condyle on right side is found to be 12.6mm, with standard deviation of ± 1.482 and with the range of 9 to 17mm where as on the left side it is 13.1 ± 1.490 mm, range being 10 to 17mm. A significant association was found between the length of right and left occipital condyle as indicated by correlation coefficient calculated by Pearson's method ($r = 0.641$). This bilateral difference is found to be significant as indicated by the result of paired t-test ($p = 0.000$, less than 0.05)

The differences between the results are possibly due to racial and geographic variations in the cranial morphometrics of the two different studied populations.

In the final assessment of morphometric asymmetry of occipital condyles it can be stated that right occipital condyle appears to be slightly longer than left this difference is nonsignificant where as left occipital condyle is found to be significantly wider than right.

Positional Asymmetry

Comparison with study done by Naderi et al.

	Opisthion-Posterior Tip Distance		Opisthion-Anterior Tip Distance		Basion-Posterior Tip distance		Basion-Posterior Tip distance	
	Right	Left	Right	Left	Right	Left	Right	Left
Naderi et al.	26.7	26.2	38.9	39.1	27.5	28.1	10.5	11.1
Present Study	28.0	28.5	38.8	38.9	26.7	27.3	11.5	12.6

Distance Between The Posterior Tip Of Occipital Condyle And Opisthion

Naderi et al found the distance between the posterior tip of occipital condyle and opisthion to be 26.7 ± 2.4 mm and 26.2 ± 2.2 mm in the right and left, respectively. Difference is significant ($p=0.035$, >0.05).⁵

In the present study it was found that the distance between the posterior tip of occipital condyle and opisthion to be 28.0 ± 2.35 mm and 28.5 ± 2.31 mm in the right and left, respectively.

Naderi et al found this distance to be greater on right side where as in present study it is found to be greater on left side. This can be explained on the basis that two different study groups can have different sagittal condylar angle on right and left as indicated by studies done by Naderi et al and Bozbuga et al. Naderi et al found sagittal condylar angle to be greater on right side (Left -29.1, Right-30.2).⁵

Bozbuga et al found sagittal condylar angle to be greater on left side (Left -29.7, Right-28.2).⁷

Distance Between The Anterior Tip Of Occipital Condyle And Opisthion

Naderi et al. found the distance between the anterior tip of occipital condyle and opisthion be 38.9 ± 2.9 mm and 39.1 ± 3.0 mm in the right and left, respectively. Difference is nonsignificant ($p=0.333$, >0.05).⁵

In the present study it was found that the distance between the anterior tip of occipital condyle and opisthion to be 38.8 ± 2.85 mm and 38.9 ± 3.36 mm in the right and left, respectively.

Difference observed is nonsignificant ($p=0.452$, >0.05).and is comparable with the study by Naderi et al.

Distance Between The Posterior Tip Of Occipital Condyle And Basion

Significant bilateral difference was observed in the distance between the posterior tip of occipital condyle and basion by Naderi and colleagues. They found the distance to be 27.5 ± 2.0 mm and 28.1 ± 2.0 mm in the right and left, respectively with p-value of 0.007.⁵ Result of present study is similar to previous one with greater distance observed on the left side than right. On the right side it was found to be 26.5 ± 2.0 mm, on the left it was 27.3 ± 2.31 mm, with the p-value being 0.004 (<0.005).

Distance Between The Anterior Tip Of Occipital Condyle And Basion

Naderi et al. found the distance between the anterior tip of occipital condyle and basion to be 10.5 ± 1.5 mm and 11.1 ± 1.5 mm in the right and left. They found the difference to be significant ($p=0.000$).⁵

In the present study this distance was found to be 11.5 ± 1.28 mm on the right side and 12.6 ± 1.38 mm. Result of paired t-test ($p=0.000$) has shown that this difference is significant.

SUMMARY AND CONCLUSION

Occipital bone with its condyles and foramen magnum represents the cranial end of craniovertebral junction. Thorough knowledge of craniovertebral junction is important for physicians of multiple disciplines such as orthopedics, neurology, ENT, radiology, neurosurgery, and skull base surgery. Morphometrics of occipital condyle and foramen magnum is especially important for newly described transcondylar approach.

Conclusions Drawn Are As Follows:

3. In the present study, mean length of occipital condyle on right side is 22.7 ± 2.294 mm with range of 16 to 29mm where as on the left side it is 22.4 ± 2.245 mm, range being 16 to 31mm.

No significant bilateral difference was found between right and left occipital condyle lengths as shown by the result of paired t-test ($p=0.770$ which is >0.05).

4. Mean width of occipital condyle on right side is found to be 12.6mm, with standard deviation of ± 1.482 and with the range of 9 to 17mm where as on the left side it is $13.1 \text{mm} \pm 1.49$ range being 10 to 17mm. Bilateral difference was found to be significant as indicated by the result of paired t-test ($p=0.000$, less than 0.05)

7. The distance between the posterior tip of occipital condyle and opisthion was found to be 28.0 ± 2.35 mm and 28.5 ± 2.31 mm in the right and left, respectively.

8. The distance between the anterior tip of occipital condyle and opisthion was found to be 38.8 ± 2.85 mm and 38.9 ± 3.36 mm in the right and left, respectively.

9. Distance between the posterior tip of occipital condyle and basion on the right side was found to be 26.51 ± 2.0 mm, on the left it was 27.31 ± 2.31 mm, with the p-value being 0.004 (<0.005).

10. Distance between the anterior tip of occipital condyle and basion was found to be 11.47 ± 1.28 mm on the right side and 12.61 ± 1.38 mm. Result of paired t-test ($p=0.000$) has shown that this difference is significant.

REFERENCES

- Berkovitz Barry KB et al. Head and Neck in: Standing Susan, editor. Gray's Anatomy: The Anatomical Basis of Clinical Practice. 39th edition. Edinburgh: Elsevier Churchill Livingstone, 2005: 459-461
- Datta AK. Essentials of Human Anatomy, Part II-Head and Neck. 4th edition. Kolkata. Current Books International, 2005; 57
- Revised and re-edited by Lewis WH, Gray's Anatomy: The Anatomy of Human Body. 20th edition. Philadelphia. Lea and Febiger, 1918.
- Babu RP, Sekhar LN, Wright DC. Extreme lateral transcondylar approach: Technical improvements and lessons learned. Journal of Neurosurgery 1994; 81: 49-59
- Sait Naderi, Esin Korman, Guven Citak, Mustafa Guvencer, et al. Morphometric Analysis Of Human Occipital Condyle. Clinical Neurology and Neurosurgery 2005; 107: 191-199.
- WEN TH, Rhoton AL Jr., Katsuta, et al. Microsurgical anatomy of the transcondylar, supracondylar, and paracondylar extension of the far-lateral approach. Journal of Neurosurgery 1997; 87: 555-585.
- Bozbuga M, Ozturk A, Bayraktar B, et al. Surgical anatomy and morphometric analysis of the occipital condyles and foramen magnum. Okajimas Folia Anat, Jpn, 1999; 75: 329-34.
- N. Muthukumar, R. Swaminathan, G Venkatesh, SP Bhamumati. A Morphometric Analysis Of The Foramen Magnum Region As It Relates To The Transcondylar Approach. Acta neurochir (Wien), 2005; 147(8): 889-895.
- Kizilkanat Emine Dondu, Boyan Neslihan, et al. Morphometry of hypoglossal canal, occipital condyle, and foramen magnum: Abstract, Neurosurgery Quarterly 2006; 16(3): 121-125
- Cicekcibas AE, Murshed KA, Ziylan T, Seker M, Tuncer I. Morphometric evaluation of some important bony landmarks on the skull base related sexes. Turk journal of medical science 2004; 34: 37-42
- Lang J. Skull Base and Related Structures in: Atlas of Clinical Anatomy (Translation into English by Juliane Kemmer). Stuttgart. Schattauer Verlagsgesellschaft mbH; 1995.
- Olivier G. Biometry of occipital bone. Journal of anatomy, 1975; 120(3): 507-518