Assessment of the atlanto-occipital junction in the MRI of subjects with cervical disc herniation

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ABSTRACT

Objectives: To demonstrate the normal limits of Powers ratio and basion dens interval in patients with disc herniations.

Methods: The MRI of patients were retrospectively evaluated by 2 radiologists. Four hundred and forty-five patients who were admitted to Duzce University Hospital with neck pain without history of trauma were chosen between January 2004 and July 2006 in this retrospective study. The patients were between the ages of 14-80 years.

Results: Four groups were identified according to the number of disc herniations. The normal limits of Powers ratio and basion dens interval were 0.77±0.15 and 0.80±0.66 in group 0, 0.76±0.14 and 0.81±0.76 in group one, 0.75±0.13 and 0.80±0.71 in group 2, 0.76±0.14 and 0.81±0.74 in group 3, and 0.77±0.16 and 0.81±0.66 in group 4. The relationship between the number of disc herniations and Powers ratio and basion dens interval was not statistically significant.

Conclusions: Our results were in concordance with the previous studies concerning the Powers ratio and basion dens interval. These 2 methods can be used in the MRI of atlantooccipital dislocation suspected patients with disc herniations.

Neurosciences 2007; Vol. 12 (4): 289-292

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Received 20th March 2007. Accepted 19th June 2007.

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Atlanto-occipital dislocations (AOD) are rare and generally fatal traumatic injuries. It is difficult to identify AOD on plain lateral cervical radiographs, especially with multiple traumas because of the peculiar anatomy and bony overlap that may lead to misdiagnosis. In suspicious cases, additional imaging with CT or MRI is recommended to achieve the secondary findings like subarachnoid and prevertebral hemorrhage or ligamentous disruption of the cervical spine.[1] There are different methods for assessing AOD, such as Powers ratio (PR), X-line method, Harris method, and basion-dens interval (BDI), which was applied on plain lateral cervical radiographs of normal subjects.[2-5] The sensitivities of these techniques are also different.[6] In particular, the role of PR is limited in cases with congenital anomalies of foramen magnum, fractures of the neural arch of the atlas, or in cases with posterior and longitudinal AOD. In the present study, our aim was to assess the normal limits of PR and BDI, the most commonly used methods, on mid-sagittal MRI of patients with cervical disc herniation.

Methods. Magnetic resonance images of the cervical spine were reviewed in 445 consecutive patients who attended Duzce University Hospital, Duzce, Turkey with neck pain related to disc herniation between January 2004 and July 2006 in this retrospective study. This study was approved by the Ethics Committee of Duzce University School of Medicine. Informed consent was obtained from the patients involved in the study. The patients were between the ages of 14-80 years. All the images were evaluated by 2 radiologists to prevent disagreements. The patients were classified according to number of disc herniations from 0 to 4. Powers ratio and BDI were applied to each patient. The Powers ratio is the ratio of the basion-posterior atlas arch (BP) to the opisthion-anterior atlas arch (OA), and is abnormal at values more than one (**Figure 1**).[2] Furthermore, Ahuja et al[1] mentioned the ratios between 0.90-1.0 as a 'gray area,' which was seen in 7% of the normal population. We also determined the number of patients in the gray area. The BDI is considered abnormal in the presence of a displacement >10 mm (12 mm in pediatrics) between these 2 structures (**Figure 2**). These methods were applied to sagittal MRI. The patients with the history of trauma were excluded. The equipment used had 1.5 Tesla field strength (Philips Intera Nova, Netherlands). T1-weighted

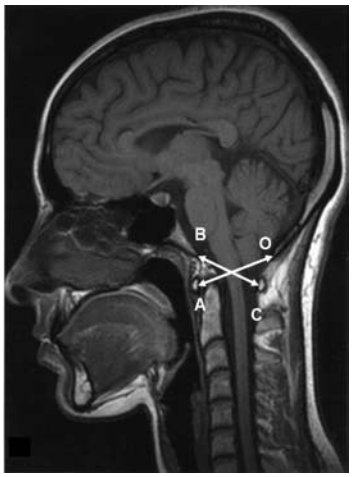

Figure 1 - Powers ratio, line segments BP/OA on T1 weighted magnetic resonance image. BP - basion posterior atlas arch, OA - opisthion-anterior atlas arch.

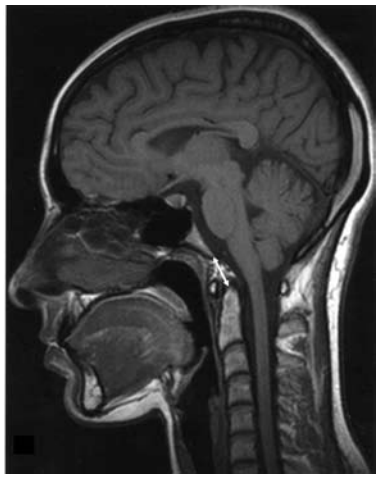

Figure 2 - Basion-dens interval on T1 weighted magnetic resonance image.

spin-echo sequences (TR= 513 ms, TE= 12 ms) of mid-sagittal images, oriented to the cervical spine were used. Slice thickness for sagittal images was 4 mm, with a one mm interslice gap. The measurements were evaluated using the DicomWorks v1.3.5 software.

The differences among the groups were determined by paired-samples t test. The relationships of all measurements with gender and age were statistically analyzed. Correlation coefficients were derived by Pearson coefficient of correlation. Descriptive statistical methods were used where appropriate. Statistical analysis was carried out using the Statistical Package for Social Science (SPSS)/PC 12.0 (SPSS Inc, Chicago, IL).

Results. The distribution of the parameters on the basis of the number of disc herniations is shown in **Table 1**. Comparison of the whole group according to gender is presented in **Table 2**. The descriptive analysis (mean, standard deviation, 95% confidence intervals for mean, minimum, and maximum values) of PR and BDI are demonstrated in **Tables 3 & 4**. The normal limits of Powers ratio and basion dens interval were 0.77±0.15 and 0.80±0.66 in group 0, 0.76±0.14 and 0.81±0.76 in group one, 0.75±0.13 and 0.80±0.71 in group 2, 0.76±0.14 and 0.81±0.74 in group 3, and 0.77±0.16 and 0.81±0.66 in group 4.

Discussion. The exact incidence of AOD is unknown due to its fatal nature. It approximately constitutes 0.67-1% of all acute cervical spine injuries.[7] In recent years, survival is more frequently reported, on the basis of immediate resuscitation, improved medical care, and imaging modalities.[8] Traynelis et al[8] classified AOD into 3 groups according to the direction of occiput displacement: type 1 is anterior displacement, which is the most common type, type 2 is vertical, and type 3 is posterior displacement. The diagnostic methods for AOD were applied on radiographs. However, the imaging techniques have developed tremendously in the last 20 years. In previous studies, these methods were performed mostly on plain lateral radiographs and CT scans of the cervical spine to compare the diagnostic accuracy.[6] Today radiographs are not performed on every patient. A CT is superior to radiography and MRI to demonstrate the multiple bony fractures. However, in some cases with pure AOD, MRI might play a

Table 1 - Distribution of the parameters on the basis of number of disc herniations.

Parameter	Group 0 N=62	Group 1 N=124	Group 2 N=143	Group 3 N=98	Group 4 N=18
Age	44.0±13.8	44.0±9.70	47.5±11.2	49.8±13.4	55.5±11.3
BDI	0.77±0.15	0.76±0.14	0.75±0.13	0.76±0.14	0.77±0.16
PR	0.80±0.66	0.81±0.76	0.80±0.71	0.81±0.74	0.81±0.66

BDI - Basion-dens interval, PR - Powers ratio

Table 2 - Comparison of the whole group on the basis of gender.

Parameter	Male N=162	Female N=283	*P*-value
Age	47.6	46.4	0.304
BDI	0.79	0.82	0.001
PR	0.75	0.76	0.473

BDI - Basion-dens interval, PR - Powers ratio

Table 3 - The results of Powers ratio in 445 patients with neck pain related to disc herniation.

Powers ratio	No.	95% Confidence Interval for mean					
		Mean	Std. Deviation	Lower Bound	Upper Bound	Minimum	Maximum
0.650-0.674	4	0.66422	0.01144	0.64602	0.68241	0.64819	0.67437
0.675-0.699	13	0.68917	0.00748	0.68465	0.69369	0.67689	0.69815
0.700-0.724	29	0.71269	0.00791	0.70968	0.71570	0.70000	0.72429
0.725-0.749	48	0.73842	0.00674	0.73646	0.74038	0.72589	0.74942
0.750-0.774	68	0.76267	0.00761	0.76083	0.76452	0.75000	0.77458
0.775-0.799	59	0.78705	0.00797	0.78498	0.78913	0.77513	0.79955
0.800-0.824	53	0.81135	0.00728	0.80935	0.81336	0.80000	0.82461
0.825-0.849	50	0.83718	0.00673	0.83527	0.83910	0.82563	0.84840
0.850-0.874	39	0.86248	0.00667	0.86032	0.86464	0.85013	0.87381
0.875-0.899	29	0.88576	0.00717	0.88303	0.88848	0.87500	0.89873
0.900-0.924	18	0.91455	0.00668	0.91123	0.91787	0.90237	0.92471
0.925-0.949	18	0.93705	0.00640	0.93387	0.94024	0.92559	0.94648
0.950-0.974	10	0.95929	0.00816	0.95345	0.96513	0.95000	0.97443
0.975-0.999	3	0.98003	0.00409	0.96987	0.99019	0.97531	0.98254
1.000-1.024	1	1.00000				1.00000	1.00000
1.025-1.049	2	1.04147	0.00960	0.95522	1.12771	1.03468	1.04826
1.075-1.100	1	1.10803				1.10803	1.10803
Total	445	0.80958	0.07262	0.80282	0.81635	0.64819	1.10803

Std. - standard

Table 4 - The results of basion-dens interval in 445 patients with neck pain related to disc herniation.

BDI	No.	95% Confidence Interval for mean						
		Mean	Std. Deviation	Std. Error	Lower Bound	Upper Bound	Minimum	Maximum
0.44-0.49	15	0.4787	0.02031	0.00524	0.4674	0.4899	0.43	0.49
0.50-0.55	10	0.5100	0.01700	0.00537	0.4978	0.5222	0.50	0.54
0.56-0.62	54	0.5919	0.00953	0.00130	00.5893	0.5945	0.58	0.62
0.63-0.68	80	0.6703	0.01414	0.00158	0.6671	0.6734	0.64	0.68
0.69-0.74	44	0.6986	0.01357	0.00205	0.6945	0.7028	0.69	0.74
0.75-0.80	91	0.7784	0.01544	0.00162	0.7751	0.7816	0.75	0.80
0.81-0.87	51	0.8435	0.02660	0.00372	0.8360	0.8510	0.81	0.87
0.88-0.93	54	0.8933	0.01614	0.00220	0.8889	0.8977	0.88	0.93
0.94-0.99	26	0.9735	0.01056	0.00207	0.9692	0.9777	0.95	0.99
1.00-1.05	7	1.0114	0.01069	0.00404	1.0015	1.0213	1.00	1.02
1.06-1.12	9	1.0800	0.01118	0.00373	1.0714	1.0886	1.06	1.09
1.13-1.18	2	1.1550	0.03536	0.02500	0.8373	1.4727	1.13	1.18
1.19-1.25	2	1.2200	0.04243	0.03000	0.8388	1.6012	1.19	1.25
Total	445	0.7585	0.14153	0.00671	0.7454	0.7717	0.43	1.25

BDI - basion-dens interval, Std. standard

crucial role in diagnosis by detecting the secondary findings such as prevertebral swelling or rupture of the neighboring ligaments.

Powers et al[7] determined the basion-posterior atlas arch to the opisthion-anterior atlas arch ratio to be 0.77±0.09 and from standard deviation, calculated that a ratio greater than 1.0 should be found in less than 1% of the normal population. They found no ratio greater than 0.98. These results were confirmed by other studies.[1,3,4,6] In the present study, PR values were in concordance with the previous studies. However, the ratio of patients in the gray area was higher (11%) compared with the study of Ahuja et al (7%).[1] Wholey et al[9] evaluated BDI, and defined this as abnormal in the presence of a displacement >5 mm (10 mm in pediatrics). Ahuja et al[1] have accepted the distance of >5 mm as abnormal referring to Wholey et al. However, Harris et al[3] reported the distance of >12 mm as abnormal, whereas Lee et al[4] interpreted the normal distance between 2-15 mm in adults, and 2-11 mm in children. Our results were in concordance with Wholey et al.[9] The relationship between the number of disc herniations and the PR and BDI values were not statistically significant. So, these methods can be used in patients with disc herniations.

In conclusion, AOD is an infrequent type of injury, which can be misdiagnosed. The PR and BDI methods can be applied easily on MRI for diagnosis of AOD in suspicious cases. Multi-center studies are necessary to increase the number of patients in order to gain more experience of AOD in the future.

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