

The Morphological Analysis of the Superior Articular Facet of the adult Human Atlas vertebra

LALIT M , PIPLANI S, KULLAR J S, ARORA A K, MANNAN R

ABSTRACT

The 'Atlas' is first cervical vertebra, supporting the "globe" of the head. The sound knowledge of the Atlas vertebra is a well established entity in Anatomy. In a number of 30 atlas vertebrae, 60 superior articular facets were studied for the presence of a constriction or a groove and a tendency to separate i.e complete or incomplete separation. On the basis of this, different shapes of the superior articular facets were also studied This study was performed in the Department of Anatomy, Government Medical

College, Amritsar. The results were compared with those of other studies and were statistically analysed. The clinical significance of this study has been thus discussed with a reference to its possible effect on the restriction of the neck at the atlanto-occipital joint.

Key Words: Superior articular facet, Presence of constriction, Groove, Tendency for separation

INTRODUCTION

Injuries of the upper cervical spine which cause severe disabilities following trauma, have always been an interesting focus for anatomists [1]. The Atlas is the first cervical vertebra which supports the "globe" of the head [2]. If the atlas was morphologically similar to other vertebrae, death would be a common result of fracture. Anatomically, the atlas is embedded in the neck muscles and is therefore protected from injury. The unique structure and the anatomical location of the atlas forms a safety mechanism [3]. Superior articular facets which are present on the atlas vertebrae face superomedially and are admirably accepted for nodding movements and also for the weight bearing of the head [4]. These are also accepted for the reception of the condyles of the occipital bone to form an atlantooccipital joint [5]. Thus, the assessment of these structures and the morphological relationship of the superior articular facet of the atlas is done before performing any clinical procedure in its proximity.

Study Design

An evaluation of the superior articular facet on the atlas vertebrae, by using dry, bony and non-pathological vertebrae.

Inclusion Criteria

1. The bones were dry, macerated and thoroughly cleaned.
2. The vertebrae were complete in all respects, in order to give the correct observations
3. The bones were non-pathological.

The instruments which were used during the present study were:

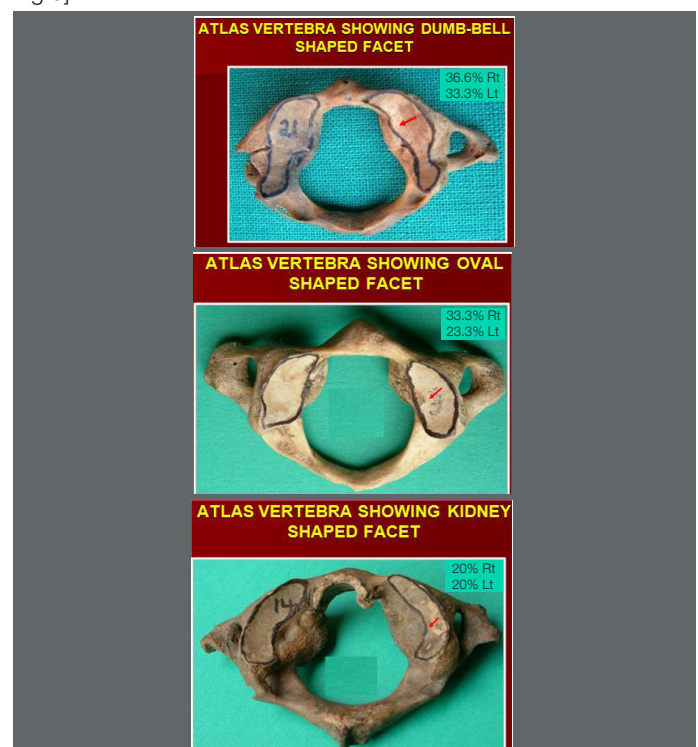
1. Hand lens
2. Lead pencil
3. Markers

MATERIALS AND METHODS

The study was conducted in the Department of Anatomy, Government Medical College, Amritsar. The material for the study comprised of 30 adult human atlas vertebrae of unknown age and sex. These were obtained by a maceration of the cadavers, which were made available for the purpose of dissection. All the atlas vertebrae were thoroughly boiled, cleaned and numbered from 1-30. Each bone was meticulously examined for the following important mor-

phological features:

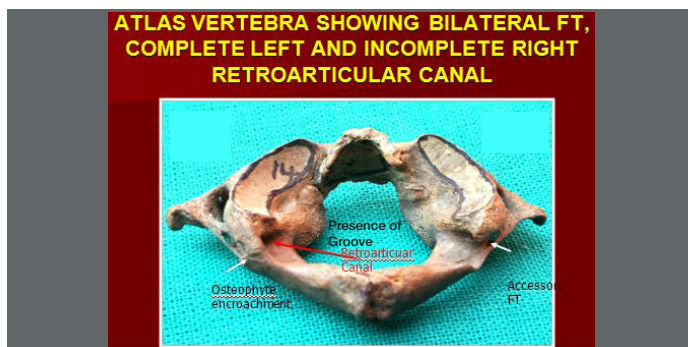
1. **The presence of a constriction:** It may be present on one or both the sides of the vertebra and shows important features like the presence of a constriction on the medial or the lateral side, a constriction on both the sides, and the absence of a constriction on both the sides of the facet [6]. [Table/Fig 1]. [Table/Fig 2]. [Table/Fig 3]



[Table/Fig 1, 2, 3]: Presence of Constriction

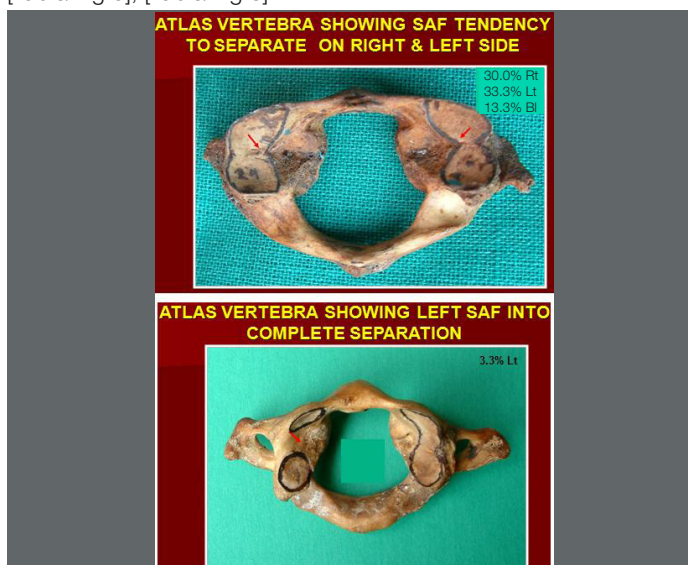
2. **The presence of a groove:** A groove of variable depth and breadth was seen to be present in the facets throughout the whole or part of the breadth of the facets i.e. in the centre or on the medial or the lateral side. Sometimes the groove is well defined and deep along the constrictions and may divide the facet into two [6]. See

[Table/Fig 4]



[Table/Fig 4]: Presence of Groove, Retroarticular canal

3. A tendency of separation: The division of the facet into two or a tendency towards it was indicated by the presence of a constriction or a groove or both. The amount of tendency of separation, was represented as absent, present, marked and well marked or as a separation into two i.e. complete and incomplete categories [6]. [Table/Fig 5], [Table/Fig 6]



[Table/Fig 5, 6]: Incomplete, complete separation

4. The shape of the Superior Articular Facet (SAF): The presence of a constriction or a groove and a tendency to separate gives the SAF different shapes which are defined as follows; Oval shape – no constriction, Kidney shape – constriction present on one side of the facet, Dumb-bell shape – constrictions on both the sides of the facet and a groove connecting these constrictions and the Fig. of eight shape – the extension of these constrictions towards the centre of the facet [6], [7]. [See Table/Fig 1-3], [Table/Fig 7]



[Table/Fig 7]: Atlas vertebra showing figure of eight shape

5. The presence of an accessory foramen transversarium was observed [See Table/Fig 4].

6. The formation of a retroarticular canal was also observed [See Table/Fig 4].

RESULTS

In 30 atlas vertebrae, the 60 superior articular facets were studied for the presence of a constriction or a groove and a tendency to separate i.e. complete or incomplete separation. Based on these observations, the percentage was calculated for each parameter and different shapes of the superior articular facets were also studied. The shape of the SAF was also statistically analysed by applying the Chi- Square test. The readings were noted and the results were compared with the findings of other workers, as shown in [Table/Fig 8-11].

Of the 60 superior articular facets which were examined, 17 facets (56.6%) showed no constriction and these were defined as oval shaped. 12 facets (40%) showed a constriction only on one side and were considered as kidney shaped. 21 facets (70%) were found to have a constriction on both the sides, which were defined as dumb-bell shaped and 10 facets (33.3%) showed a constriction on both the sides along with a groove in the centre of the facet, which were considered as the ‘figure of 8’ shape. The Chi-Square test was applied to evaluate the percentages of the types of the shapes on the right and left sides of the superior articular facet and the difference between these was found to be statistically insignificant (p=0.536) Incomplete separation was seen on 2 facets (6.6%) on the right and left sides individually, whereas a complete separation was seen only on one facet (3.3%) on the left side

DISCUSSION

For comparing the results of the present study with those which were reviewed, only the findings of the authors who studied skeletal material were taken into account and these are shown in the [Table/Fig 8], [Table/Fig 9], [Table/Fig 10] and [Table/Fig 11] as follows:

Workers	Year	Population	SAF	Constriction						Total (N)		
				Absent		Medial side of facet		Lateral side of facet			Both sides of facet	
				No.	%	No.	%	No.	%		No.	%
Shamsher Singh [6]	1965	Varanasi	Right	53	26.5	8	4	5	2.5	134	67	200
			Left	42	21.0	6	3	14	7.0	138	69	200
Present study	2009	North Indian	Right	10	33.3	4	13.3	2	6.66	14	46.6	30
			Left	7	23.3	3	10	3	10.0	17	56.6	30

[Table/Fig 8]: Comparison of presence of constriction

Workers	Year	Population	No.	Groove							
				Absent	Left facet			Right facet			Bilat. facet
					No.	%	No.	%	No.	%	
Shamsher Singh ⁶	1965	Varanasi	200	52	26	23	11.5	16	8	109	54.5
				13	43.3	3	10.0	3	10.0	11	36.6
Present study	2009	North Indian	30	13	43.3	3	10.0	3	10.0	11	36.6

[Table/Fig 9]: Comparison of presence of groove

Amount of separation	Shamsher Singh (1965)6 Varanasi Population (200 vertebrae)						Present study (2009) North Indian Population (30 vertebrae)					
	Left facet		Right facet		Both facet		Left facet		Right facet		Both facet	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
None	11	5.5	17	8.5	29	14.5	1	3.3	3	10.0	12	40

Present	17		18		12		4		3		3	
Marked	40	52	36	40.5	22	24.5	3	33.3	4	30.0	1	13.3
Well marked	47		27		15		3		2		-	
Incomplete	19	9.5	10	5.0	5	2.5	2	6.6	2	6.6	-	-
Complete	10	5	6	3	3	1.5	1	3.3	-	-	-	-
Total		114		114		86		14		14		16

[Table/Fig 10]: Comparison of tendency of separation

Worker	Year	Population	N	Shape (SAF)	Rt. SAF		Lt. SAF		Total	
					N	%	N	%	N	%
Francis ⁷	1955	Negros & Whites	328	Oval Reniform Dumbbell	-	-	-	-	-	-
Singh ⁶	1965	Varanasi	200	Oval	53	26.5	42	21	-	-
				Reniform	13	6.5	20	10	-	-
				Dumb-bell	134	67	138	69	-	-
				F8						
Gupta & Goel ⁸	2000	Maharashtrian	50	Oval	-	-	-	-	74	74
				Reniform	-	-	-	-	24	24
Present Study	2009	North Indians	30	Oval	10	33.3	7	23.3	17	56.6
				Reniform	6	20	6	20	12	40
				Dumb-bell	11	36.6	10	33.3	21	70
				F8	3	10	7	23.3	10	33.3

[Table/Fig 11]: Comparative incidence and types of shape of superior articular facet of atlas

1. The presence of a constriction: It is clear from Table/Fig 8, that the presence of a constriction on the individual sides of the facets had a higher value in the present study, as compared to the results recorded by Singh, whereas a constriction which was observed on both sides of the facets, in the present study had a lower value as compared to that which was observed by Singh [8], [9].

The Superior articular facets face superomedially [4] and for the reception of the condyles of the occipital bone to form an atlantooccipital joint [5]. An atlanto occipital transarticular approach is useful for the anterior extradural lesions of the cranio vertebral junction at this point [9]. An abnormal hypertrophy of the articular facets is again a recognized cause for the narrowing of the vertebral canal and consequent neurological feature [10]. In severe cases of ossification, sometimes a complete bridge is formed across the posterior arch of the atlas surrounding the vertebral artery, which is called as the retroarticular canal or the vertebral artery ring of the atlas vertebra [11] This arterial ring may sometimes be bridged by fibrous tissue i.e. the oblique ligament of the atlas [11] can ossify completely or incompletely, thus forming a complete or incomplete bony ring [12] as seen in Table/Fig 4

2. The presence of the groove: As can be evaluated from the comparative analysis of Table/Fig 9, in the present study, the grooves on the right and left facets were found to be in 3 cases each (10%), which was comparable with the work of Singh, but the groove on both the facets was seen in 11 cases (36.6%), thus carrying a lesser value in the north Indian population. No groove was found in 13 cases (43.3%), thus showing a higher value than that which was reported by Singh. These grooves may give rise to pressure facets which are smooth circular impressions which are present on the medial sides of the articular surfaces. These pressure facets indicate a greater pressure at these sites during movement at the atlanto-occipital joints [6]. At the junction of the posterior arch, with the lateral masses holding the superior articular facets on each side, the posterior arch is hollowed out above, to form a smooth groove for the lodgment of the first part of the vertebral artery with the venous plexus around it and the suboccipital nerve (dorsal ramus of the first cervical nerve). The groove is occasionally converted into a foramen or a short canal by a bony arch [13]. (as seen in Table/Fig 4) The knowledge of the quantitative anatomy

of the vertebral artery groove on the posterior arch of the atlas will prove useful to the surgeons who perform operative procedures in this region and will thus help in avoiding vascular complications like vertebrobasilar insufficiency. There is a reduction in the blood flow in the vertebrobasilar circulation [15] and this may manifest as a variety of signs and symptoms, from dizziness to unconsciousness and death [15]. Such a compromised blood flow may be due to the serpentine course and the multiple loops of the vertebral artery with respect to the atlas [16]. The vertebral artery, the first cervical nerve and the vertebral plexus which passes through the vertebral ring can be compressed, thus causing basilar insufficiency and symptoms like: pain in the temporal region and in the back of the eye, occipital headache, periodic photophobia, paraesthesia of the hands and a sensation of pressure on the hands, thus leading to a diagnosis of: psychogenic tension, functional headache, depression, cervical pain and stress [17].

3. Tendency for Separation: The findings of the present study were compared with the previous observations, as shown in the Table/Fig 10. The tendency to separate in the present study, showed no significant difference between the right and left facets (33.3%-Lt. facet; 30%-Rt. facet and 13.3%-both facets). Incomplete separation in the present study, was found to be the same in the right and left facets (6.6%), but complete separation into two was more frequent on the left side as compared to the right facet. The results of the study by Singh account for a higher value in the amount of separation in the Varanasi population as compared to those of the present study. The tendency of the SAF of the atlas to split into two (as seen in Table/Fig 5 and 6) is an indication of the further restriction of the movement at the atlanto-occipital joint [6]. The incidence of the division of the SAF of the atlas is of anthropological interest [18].

4. The Shape of the Superior Articular Facet (SAF): Table 11 depicts the different shapes of the SAF as was observed by different authors. The present study thus reported the shape of the SAF in a majority of the cases as a dumb-bell shape followed by an oval shape, a reniform and a figure of eight (F8). (See Figs.1, 2, 3 and 4) Francis (1955) gave no comparative data but defined only the shapes, whereas Singh (1965) reported a combined dumbbell and F8 as the commonest shape and Gupta (2000) defined only two shapes and found the oval as the commonest. The difference between the percentages of the types of shapes on the right and left sides of the superior articular facet was found to be statistically insignificant ($p=0.536$). None of the earlier authors have compared the parameters of both the sides in the available accessible literature. The occurrence of osteophytes in the vertebral column is well known to anatomists, clinicians and anthropologists. Osteophytes may appear on the atlas characteristically in the region of the superior articular facets (as seen in the Table/Fig 4). Vertebrobasilar ischaemia due to the compression of the vertebral arteries, which is caused by the osteophytes, may also occur [19].

SUMMARY AND CONCLUSIONS

The difference between the values of the present study and those observed by other authors may be due to racial factors, different living conditions or the environment. The difference between the percentages of the types of shapes on the right and left side of the superior articular facet was found to be statistically insignificant ($p=0.536$). None of the earlier authors have compared the parameters which are related to the shapes on both the sides in the available accessible literature. **To conclude, it can be stated that:**

1. Division of one facet into two or a tendency towards it is indicated by the presence of a constriction or a groove or both
2. These grooves may give rise to pressure facets which are smooth circular impressions which are present on the medial sides of the articular surfaces. In some cases, these pressure facets are so marked that the rest of the articular area looks non articular. These pressure facets indicate a greater pressure at these sites during movement at the atlanto-occipital joints.
3. The tendency of the superior articular facet of the atlas to split into two, is an indication of restricted movements at the atlanto-

occipital joint

4. The superior articular facet of the atlas with a different shape i.e an oval kidney dumb-bell shape, is also an indication of the further restriction of the movements at the atlanto-occipital joint.
5. Congenital osseous craniovertebral junction malformations are the most common compressive lesions. The presence of myriad bony configurations like the angulation or the rotation of the atlas and the asymmetry of the facet joint may lead to incomplete decompression [20].
6. The occurrence of osteophytes in the vertebral column is well known to anatomists, clinicians and anthropologists. Osteophytes may appear on the atlas characteristically in the middle of the anterior arch, either on the superior or the inferior border. They may also occur on the posterior arch. Vertebrobasilar ischaemia due to the compression of the vertebral arteries, which is caused by the osteophytes, may also occur [16].
7. Superior and inferior articular processes form a solid articular pillar that transmits some weight from one vertebra to the next lower vertebra [21]. Abnormal hypertrophy of the articular facets is again a recognized cause for the narrowing of the vertebral canal and consequent neurological features [22].
8. The vertebral and the basilar arteries contribute blood not only to the brain, but also to the inner ear and their spasm may be manifested not only by neurological symptoms, but also by labyrinthine or hearing disturbances [17].
9. It is possible that extreme rotation movements at the cervical spine in an individual with an associated bony canal may result in the compression of the vertebral artery and compromised blood flow. Thus, these anatomical features should be taken into account in the therapeutic manipulation of the cervical spine [15].
10. The knowledge of the quantitative anatomy of the vertebral artery groove on the posterior arch of the atlas will prove useful to the surgeons who perform operative procedures in this region and will thus help in avoiding vascular complications [14].
11. In recent years, considerable innovations in the internal fixation techniques have created a need for a more detailed quantitative description of the anatomy of this bone [23].
12. Thus, the anatomy of the cervical vertebrae or the spine is of high clinical importance to surgeons, as a surgical procedure may be done through the anterior or posterior cervical spine with gratifying results [24].

REFERENCES:

- [1] Bohlman HH. Acute fractures and dislocations of the cervical spine. *J Bone and Joint Surgery* 1979; 61-A(8): 1119-1141.
- [2] William M, Newell RLM, Collin P. The back: cervical vertebrae. In: Standing S, Ellis H, Haely JC, Johnson D, Williams A, Gray's Anatomy. 39th edition. Edinburg, London: Elsevier Churchill Livingstone; 2005: 742-746.
- [3] Landells CD, Peteghem KV. Fractures of the atlas: classification, treatment and morbidity. *Spine* 1988; 13(5): 450-452.
- [4] Bryce TH. Osteology the skeleton – Vertebral column. In: Schaffer EA, Symington J, Bryce TH, Editors. Quains elements of anatomy. 11th edition. London: Longmans Green and Co; 1915: 5-34.
- [5] Grant JCB. Cervical vertebrae. In: An atlas of anatomy by regions. 2nd edition. Baltimore, USA: The Williams and Wilkins Company; 1948: 268-274.
- [6] Singh S. Variations of the superior articular facets of the atlas vertebrae. *J Anat* 1965; 99(3): 565-571.
- [7] Francis CC. Variations in the articular facets of the cervical vertebrae. *Anat Rec* 1955; 122: 589-602.
- [8] Gupta S, Goel A. Quantitative anatomy of the lateral masses of the atlas and axis vertebrae. *Neural India* 2000; 48: 120-125.
- [9] Kawashima M, Tanriover N, Rhodon AL, Ulm AJ, Matsushima T. Extreme lateral variants of the atlanto occipital transarticular approach to anterior extradural lesions of the cranio vertebral junction – Anatomical reports. *Neurosurgery* 2003; 53(3): 662-675.
- [10] Gupta M, Bharihoke V, Bhargava SK, Agarwal N. Size of the vertebral canal – A correlative study of measurements in radiographs and dried bones. *J Anat Soc India* 1998; 47: 1-6.
- [11] Anson BJ, Rea RL. Axial skeleton – cervical vertebrae. In: Morris Human Anatomy – A complete systematic treatise. 12th edition. New York, Toronto, Sydney, London: The Blakiston division McGraw Hill Book Company; 1966: 142-147.
- [12] Gupta T. Quantitative anatomy and vertebral artery groove on the posterior arch of atlas in relation to spinal surgical procedures. *J Anat Soc India* 2008; 57(1): 53-89.
- [13] Macalister A. Notes on the development and variations of the atlas. *J Anat and Physiol* 1893; XXVII: 519-542.
- [14] Lamberty BGH, Zivanovic S. The retroarticular vertebral artery ring of the atlas and its significance. *Acta Anat* 1973; 85: 113-122.
- [15] Mitchell J. The incidence and dimensions of the retroarticular canal of the atlas vertebra. *Acta Anat* 1998; 163: 113-120.
- [16] Cacciola F, Phalke U and Goel A. Vertebral artery in relationship to C1 – C2 vertebrae: An anatomical study. *Neurology India* 2004; 52(2): 178-184.
- [17] Taitz C, Nathan H, Arensburg B. Anatomical observations of the foramina transversarium. *J Neurology, Neurosurgery and Psychiatry* 1978; 41: 170-176.
- [18] Maheshwari J. Spinal Injuries. In: Essential orthopaedics. 3rd edition. New Delhi. Mehta publishers; 2002: 143-152.
- [19] Nathan H. Osteophytes of the vertebral column- An anatomical study of their development according to age, race and sex with considerations as to their etiology and significance. *J Bone and Joint Surg* 1962; 44-A(2): 243-268.
- [20] Jain VK, Behari S, Banerji D, Bhargava V, Chhabra DK. Transoral decompression for craniovertebral osseous anomalies perioperative management dilemmas. *Neurol India* 1999; 47: 188-195. 118
- [21] Inderbir Singh. Cervical vertebrae. In: Textbook of human Osteology. 2nd edition. New Delhi: Medical Publishers LTD; 2002: 98-103.
- [22] Gupta M, Bharihoke V, Bhargava SK, Agarwal N. Size of the vertebral canal – A correlative study of measurements in radiographs and dried bones. *J Anat Soc India* 1998; 47: 1-6.
- [23] Landells CD, Peteghem KV. Fractures of the atlas: classification, treatment and morbidity. *Spine* 1988; 13(5): 450-452.
- [24] McCormack, Weinstein PR. Cervical spondylosis – An update. *West J Med* 1996; 165(1-2): 43-51.

AUTHORS:

1. Dr. MONIKA LALIT
2. Dr. SANJAY PIPLANI
3. Dr. J.S. KULLAR
4. Dr. ANTERPREET KAUR ARORA
5. Dr. RAHUL MANNAN

NAME OF DEPARTMENT(S) / INSTITUTION(S) TO WHICH THE WORK IS ATTRIBUTED:

Dept of Anatomy, Chintpurni Medical College, Pathankot, Punjab, India.
 Dept of Pathology, SGRDIMS& Research, Amritsar-143001, Punjab, India.
 Dept of Anatomy, Government Medical College, Amritsar-143001, Punjab, India.
 Dept of Anatomy, SGRDIMS& Research, Amritsar-143001, Punjab, India.

NAME, ADDRESS, PHONE, E-MAIL ID OF THE CORRESPONDING AUTHOR:

Dr. Monika Lalit, 24, Lane-5, Gopal Nagar, Majitha Road, Amritsar-143001, Punjab, INDIA
 E Mail: monika.lalit@yahoo.com

DECLARATION ON COMPETING INTERESTS: No competing Interests

Date of Submission: **Jan 20, 2011**
 Peer Review Completion: **Feb 26, 2011**
 Date of Acceptance: **Mar 05, 2011**
 Date of Publication: **Apr 11, 2011**