Correspondence

The incidence of the lateral bridge of the atlas vertebra

The vertebral artery, in its course from the subclavian artery to the basilar artery, is vulnerable to damage or distortion from external factors such as bony, ligamentous or muscular structures (Mehalic & Farhat, 1974; Parkin et al. 1978; Schellhas et al. 1980; Braun et al. 1983; Dunne et al. 1987; Fast et al. 1987). In the atlas vertebra, the retroarticular canal and the lateral bridge are examples of bony outgrowth or exostosis which may cause external pressure on the vertebral artery as it passes from the foramen transversarium of the vertebra to the foramen magnum of the skull. If this pressure is severe enough, as may occur during the extreme rotatory movements carried out during therapeutic manipulation of the cervical spine, the vertebral artery may be compressed (Lambert & Zivanovic, 1973), reducing its cross-sectional area, and compromising its blood flow (Taitz & Nathan, 1986). Vertebralbasilar ischaemia from compression of the vertebral arteries by osteophytes is an uncommon occurrence under normal circumstances (Warlow, 1996).

There are few studies of the lateral bridge of the atlas reported in the literature (MacAlister, 1869, 1893; Lamberti & Zivanovic, 1973; Saunders & Popovich, 1978; Taitz & Nathan, 1986). The lateral bridge was first described by MacAlister (1869, 1893) as a variety of the ‘posterior glenoid process’ (the retroarticular canal), which he termed the ‘gleno-transverse bony arch’. As its name implies, it is a lateral outgrowth of bone from the superior articular facet or lateral mass to the posterior root of the transverse process of the atlas (MacAlister, 1869, 1893; Lamberti & Zivanovic, 1973; Saunders & Popovich, 1978; Taitz & Nathan, 1986). The retroarticular canal is formed by an exostosis passing from the posterior surface of the lateral mass to the posterior margin of the vertebral artery groove of the atlas. Thus the lateral bridge forms another arch, secondary to the retroarticular canal, through which the vertebral artery must pass (MacAlister, 1869).

The lateral bridge of the atlas rarely occurs in isolation but is thought to be associated with the more commonly found retroarticular canal. Like the retroarticular canal, it is a common structure in lower vertebrates, but also occurs in primates (Lamberti & Zivanovic, 1973). In humans, the incidence of the lateral bridge has been reported to be as little as 3.8% in American white and black subjects (Taitz & Nathan, 1986) but there are no reports on the incidence of this anatomical structure in the South African population. It was the aim of this study, therefore, to assess the incidence of the lateral bridge, secondary to the retroarticular canal of the atlas, in the South African white and black, female and male adult population.

Complete/undamaged atlas vertebrae of black and white, male and female individuals aged between 20 and 80 y were selected from the Raymond A. Dart Skeletal Collection of the Department of Anatomical Sciences, University of the Witwatersrand. This collection of approximately 3000 South African black, white and mixed race disarticulated skeletons has been compiled over the past 70 y from cadaver material used by medical and allied medical students in the study of anatomy. The total number of 180 vertebrae which possessed left-only (65 vertebrae), right-only (31 vertebrae) or bilateral (84 vertebrae) retroarticular canals formed the sample used in this study. These atlas vertebrae were examined for evidence of further exostosis from the lateral border of the superior articular facet and from the posterior root of the transverse process in the region of the posterolateral border of the foramen transversarium (Fig.). The specimens exhibiting such bony outgrowth were classified as having either a partial or a complete left and/or right lateral bridge of the atlas. The χ² test was used to determine any significant differences between the frequencies of the lateral bridge in the various groups.

The incidence of the lateral bridge of the atlas vertebra for the total sample and for each of the white, black, female and male groups, is shown in the Table. It is of interest to note that of the total number of sides of the atlas vertebrae with the retroarticular canal used in this study (264), 147 (55.68%) also had some form of a lateral bridge, but only 18 (6.82%) of these 264 sides had a complete lateral bridge. That is, 12.24% (18) and 87.76% (129) of the lateral bridges of the atlas vertebrae were of the complete and incomplete forms respectively (Table) ($\chi^2 = 8.28; 1$ df; $P < 0.001$). The highest incidence of the complete lateral bridge of the atlas vertebra (17.78%) was found in the black female group (Table) ($\chi^2 = 8.00; 1$ df; $P < 0.01$), although in the total sample, the number of lateral bridges which occurred with a bilateral retroarticular canal of the atlas vertebrae appeared to increase with age after 40 y. No bilaterally occurring lateral bridges were found in any of the groups studied.

The incidence of the complete (12.24%) and incomplete (87.76%) lateral bridge of the atlas, found in the present study in a sample of vertebrae exhibiting a retroarticular canal, does not support the work of Taitz & Nathan (1986). These authors reported frequencies of 69% and 31% for the complete and incomplete lateral bridge in a sample of American white and black females and males. Furthermore, they found that 3.8% of vertebrae showed this anatomical variation. However, they may have used their total sample of vertebrae (672) in their calculations, including atlas vertebrae which did not exhibit the retroarticular canal as well, which would account for the lower incidence of the lateral bridge reported. In the present study, the lateral bridge of the atlas was examined as an example of exostosis associated with the retroarticular canal (an incidence of 9.7% in a sample of 1354 vertebrae (personal unpublished data)). Therefore, only those vertebrae exhibiting the latter structure were included in the sample of South African whites and blacks examined. This may account for the higher incidence of the lateral bridge found in this study. Although there was a significantly higher frequency of the complete lateral bridge of the atlas in the South African
Fig. A superolateral view of the atlas vertebra showing a left partial lateral bridge (arrows) and associated retroarticular canal. A, anterior; P, posterior; LB, lateral bridge; RAC, retroarticular canal; SAF, superior articular facet; TVF, foramen transversarium.

### Table. Incidence of the lateral bridge of the atlas vertebra

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<tr>
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<th>Complete</th>
<th>Incomplete</th>
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<tr>
<td></td>
<td>N</td>
<td>n (%)</td>
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<td>------------------</td>
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<tr>
<td>Total sample</td>
<td>147</td>
<td>18 (12.24)</td>
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<tr>
<td>White females</td>
<td>13</td>
<td>1 (7.69)</td>
</tr>
<tr>
<td>White males</td>
<td>9</td>
<td>— (0.00)</td>
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<tr>
<td>Black females</td>
<td>45</td>
<td>8 (17.78)</td>
</tr>
<tr>
<td>Black males</td>
<td>80</td>
<td>9 (11.25)</td>
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</tbody>
</table>

N, total number of lateral bridges of the atlas vertebra; n, number of complete/incomplete lateral bridges of the atlas vertebra.

black females (17.78%) when compared with the other subgroups, the sample sizes were small (Table). Therefore, it is apparent that the results of the present study suggest trends only in the incidence of the lateral bridge of the atlas in the different South African population and age groups studied.

Considering the total sample of South African atlas vertebrae in which the lateral bridge was found (18), the number of lateral bridges occurring with the retroarticular canal appears to increase with age, after 40 y. This may be interpreted as an increase in exostosis from the edges of the articular facets, for instance, as a result of degenerative changes (Nathan, 1962), and which may be associated with ageing (Taitz & Nathan, 1986). However, this was not found in the black female group in the present study. This view is opposed, too, by Saunders & Popovich (1978) who suggested that soft tissue sclerosis is not associated with old age. These authors found evidence of the retroarticular canal and an associated lateral bridge of the atlas in adults and children, and concluded that atlas bridging is familial rather than age-related. On the other hand, because this anatomical variation is common in lower animals such as primates, Lamberty & Zivanovich (1973) suggested that where it occurs in humans, it is indicative of regression in the atlas.

In those atlas vertebrae which have a complete retroarticular canal, the present study found that 55.68% also have a lateral bridge. This evidence of a greater degree of exostosis in these vertebrae imply that, in these cases, the vertebral artery must pass through 2 bony canals in the atlantocranial region. In itself, this anatomical variation may not cause changes in the normal blood flow through the vertebral artery. However, it is in this region that the vertebral artery is particularly vulnerable to compression during extreme rotation of the head and neck, as occurs in manipulation of the cervical spine, when the vessel is stretched on the side contralateral to the rotation (Selecki, 1969; Parkin et al. 1978; Krueger & Okazaki, 1980; Schellhas et al. 1980; Bolton et al. 1989). Therefore, it is possible that extreme rotation movements of the cervical spine in an individual with a lateral bridge of the atlas and an associated retroarticular canal may result in increased compression of the vertebral artery, within these
bony confines, and compromised blood flow. Thus, these anatomical factors should be taken into account in the therapeutic manipulation of the cervical spine.

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