

Dural and pial pain-sensitive structures in humans: new inputs from awake craniotomies

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Our knowledge on intracranial pain-sensitive structures in humans comes essentially from observations during neurosurgical procedures performed in awake patients. It is currently accepted that intracranial pain-sensitive structures are limited to the dura mater and its feeding vessels and that small cerebral vessels and pia mater are insensitive to pain, which is inconsistent with some neurosurgical observations during awake craniotomy procedures. We prospectively collected observations of painful events evoked by mechanical stimulation (touching, stretching, pressure, or aspiration) of intracranial structures during awake craniotomies, routinely performed for intraoperative functional mapping to tailor brain tumour resection in the eloquent area. Intraoperatively, data concerning the locations of pain-sensitive structures were drawn by the surgeon on a template and their corresponding referred pain was indicated by the patient by drawing a cross on a diagram representing the head. Ninety-three painful events were observed and collected in 53 different patients (mean age 41.2 years, 25 males) operated on awake craniotomy for left (44 cases) or right (nine cases) supra-tentorial tumour resection in eloquent areas. On average, 1.8 painful events were observed per patient (range 1–5). All the painful events were referred ipsilaterally to the stimulus. In all cases, the evoked pain was sharp, intense and brief, stopped immediately after termination of the causing action, and did not interfere with the continuation of the surgery. In 30 events, pain was induced by stimulation of the dura mater of the skull base (23 events) or of the falx (seven events) and was referred predominantly in the V1 territory and in the temporal region. In 61 cases, pain was elicited by mechanical stimulation of the pia mater or small cerebral vessels of the temporal (19 events), frontal (25 events), parietal (four events) lobes and/or the peri-sylvian region, including the insular lobe (13 events), and referred in the V1 territory. In this observational study, we confirmed that dura of the skull base and dura of the falx cerebri are sensitive to pain and that their mechanical stimulation induced pain mainly referred in the sensory territories of the V1 and V3 divisions of the trigeminal nerve. Unlike earlier studies, we observed that the pia and the small cerebral vessels were also pain-sensitive, as their mechanical stimulation induced pain referred mainly in the V1 territory. These observations suggest that small pial cerebral vessels may also be involved in the pathophysiology of primary and secondary headaches.

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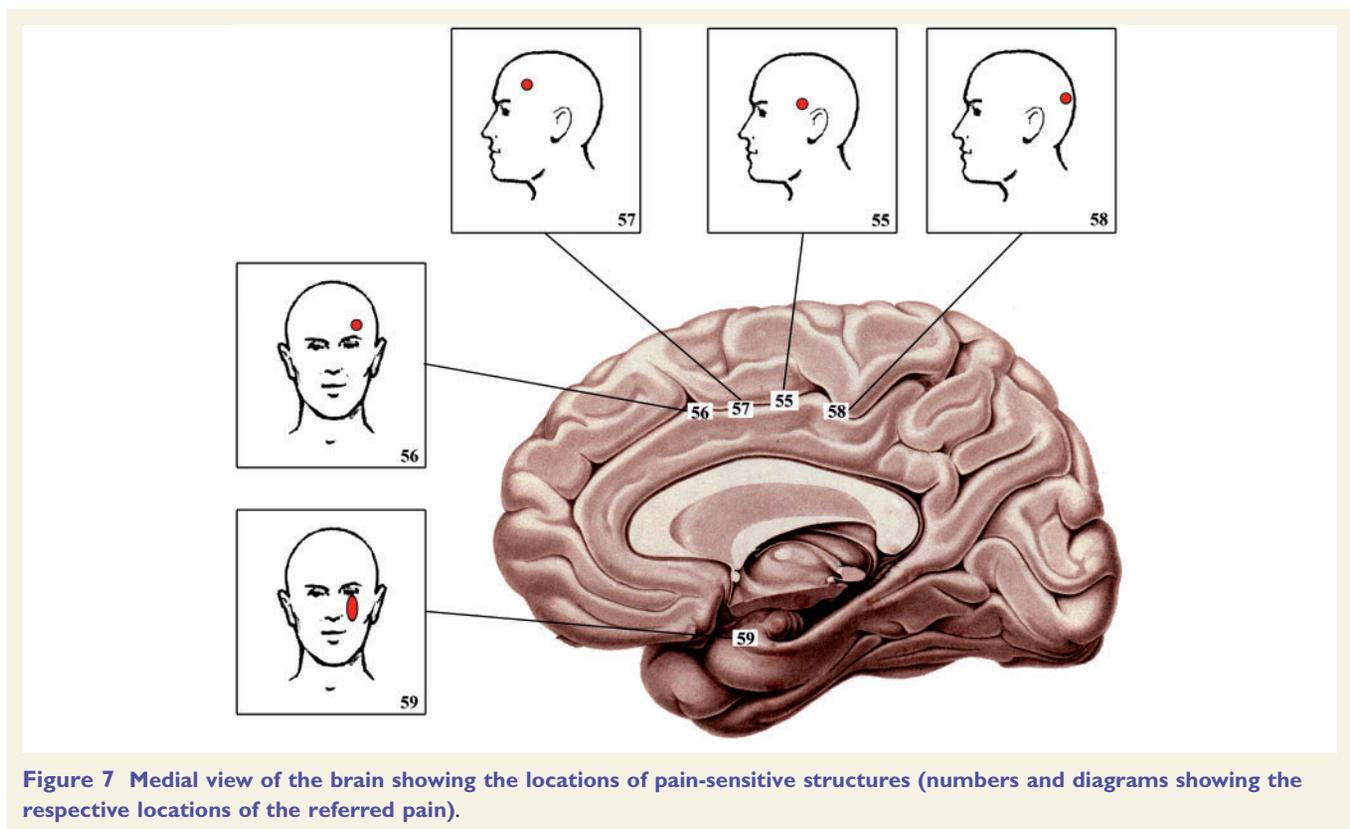


Figure 7 Medial view of the brain showing the locations of pain-sensitive structures (numbers and diagrams showing the respective locations of the referred pain).

pain (Goadsby *et al.*, 2009; Burstein *et al.*, 2011). However some authors have suggested that Ray and Wolff might have not documented all the intracranial pain sensitive structures and that diffuse, long-term, low-grade noxious activation of pial nociceptors could play a crucial role in the initiation of the headache phase of migraine (Olesen *et al.*, 2009). Our findings support this hypothesis, especially the similarity between the locations of referred pain after stimulation of the small pial arteries in the V1 territory and the referred pain patterns in migraine headache. Moreover, displacement and stretching of small cerebral vessels may play a role in headache due to intracerebral tumours or expansive lesions. However intraoperative provoked pain was sharp and brief, and differed from long-lasting pain observed migraine or secondary headache. Our study is insufficient to clarify the exact role of the small cerebral vessels in the pathophysiology of headache but points them out as a potential source of headache.

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Conclusion

In this observational study, we collected prospectively 93 reports of acute and brief pain events evoked by mechanical stimulation of intracranial structures in 53 patients undergoing an awake craniotomy for brain tumour resection. We confirmed that dura of the skull base and dura of the falx cerebri are sensitive to pain and that their mechanical stimulation induced pain mainly referred in the sensory territories of the V1 and V3 divisions of the trigeminal

nerve. Unlike earlier studies, we observed that the pia and the small cerebral vessels were also pain-sensitive, as their mechanical stimulation induced pain referred mainly in the V1 territory. These observations suggest that small pial cerebral vessels may also be involved in the pathophysiology of primary and secondary headaches.

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