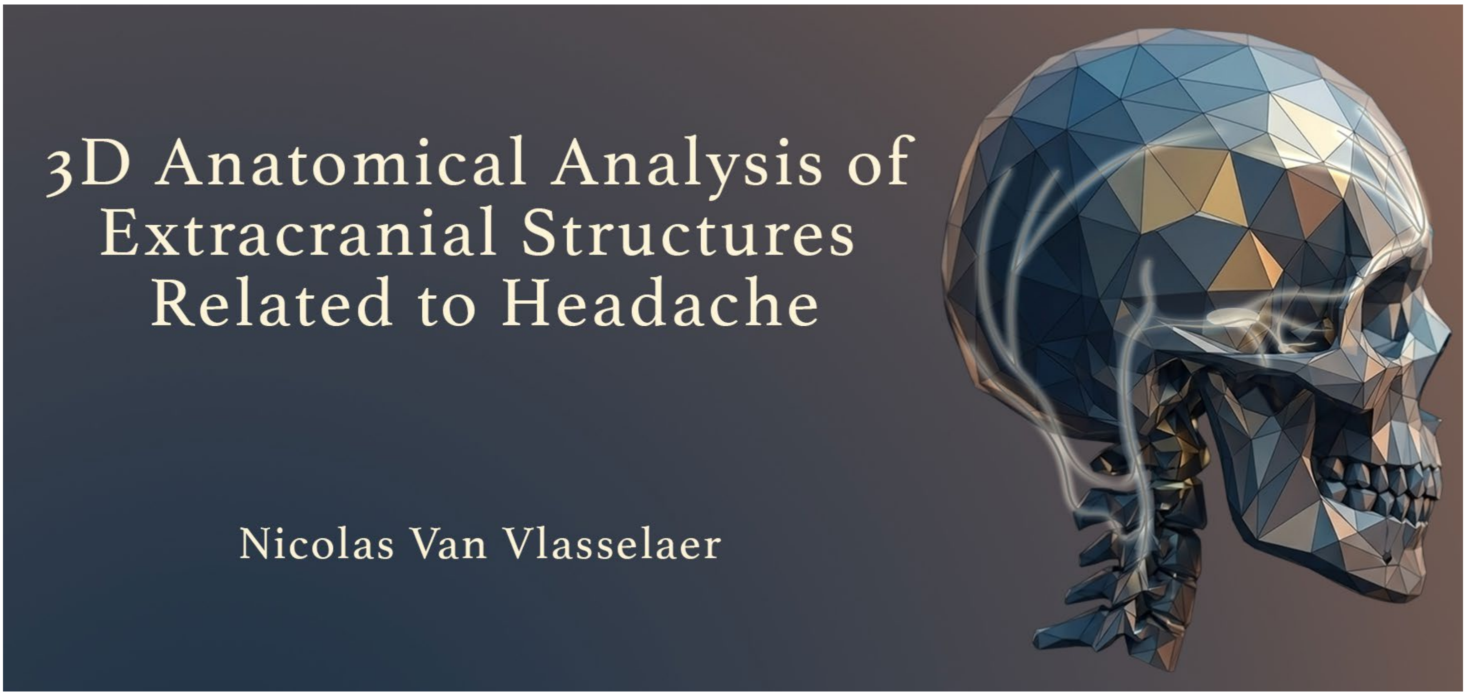

3D ANATOMICAL ANALYSIS OF EXTRACRANIAL STRUCTURES RELATED TO HEADACHE

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PUBLIC PHD DEFENCE FOR THE DEGREE OF
DOCTOR IN Rehabilitation Sciences and Physiotherapy

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ABSTRACT OF THE RESEARCH

Headache is often thought of as a problem that starts inside the skull, for example in the brain, blood vessels, or its surrounding membranes. However, existing research indicates that structures outside the skull are also relevant to headache.
Nerves in the scalp, small joints in the neck, muscles, connective tissues, and deep structures at the base of the skull are linked to pain pathways that converge in the trigeminocervical complex, a region where signals from the head and upper neck come together. This does not mean that these structures are always the cause of headache. Rather, they form an important anatomical background for understanding why headache symptoms can be complex, difficult to localize, and different from one person to another.

The aim of this PhD was to describe several of these extracranial structures in three dimensions and to understand how much normal variation exists between people. To do this, I combined anatomical dissection, dry bone analysis, CT scans, MRI, digital 3D measurements, and photogrammetry. Photogrammetry is a technique that creates a three-dimensional model from a large series of photographs. By combining these methods, it became possible not only to study anatomy in detail, but also to test how accurately different imaging techniques represent that anatomy.

Across the different studies, one message returned again and again: anatomy is much less uniform than textbooks often suggest. The small joints of the cervical spine frequently showed asymmetry and wear that differed from left to right. Important nerves of the head and neck, such as the supraorbital, greater occipital, and third occipital nerves, followed variable paths from one individual to another. In one study, a small groove-like notch was often found where the third occipital nerve crosses the C2-C3 facet joint, especially when that joint showed degeneration.
This may be relevant for understanding certain forms of occipital or neck-related headache. At the skull base, the anatomy of the foramen ovale and the access routes to the sphenopalatine ganglion also showed important differences that may affect interventions.

New three-dimensional techniques can greatly improve anatomical research, but they must be used critically. CT proved useful for measuring some skull base structures, while MRI was less reliable for showing the so-called myodural bridge, a connective tissue link between suboccipital muscles and the spinal dura. Photogrammetry, on the other hand, turned out to be a promising and accessible way to build accurate 3D models of bones and dissected body donor material. This means anatomy can be documented and studied in far greater detail than before, without relying only on traditional 2D measurements in dissections or expensive imaging methods.

The broader importance of this work is that it provides a stronger anatomical basis for a more personalized view of headache. Rather than assuming that everyone has the same anatomy, these findings show that potentially relevant extracranial structures can vary substantially from person to person. That matters when scans are interpreted, when anatomy-based procedures are planned, and when future researchers try to connect anatomical variation with symptoms. Better three-dimensional knowledge of extracranial anatomy may therefore support safer and more precise approaches, while also improving the foundation for future headache research.

In summary, this PhD does not claim that anatomy alone explains headache. Instead, it shows that the anatomy around the head and upper neck can be mapped in detail, varies considerably between individuals, and deserves attention in headache research. By combining anatomical research with modern 3D techniques, this work helps build a stronger foundation for future research and for more anatomy-aware headache care.

CURRICULUM VITAE

As a physiotherapist, anatomy and biomechanics researcher, and teaching assistant at the Vrije Universiteit Brussel (VUB), I have a background in human anatomy, musculoskeletal research, and three-dimensional anatomical analysis. My research experience includes 3D anatomical modelling, CT-based imaging, experimental anatomy, and the investigation of anatomical variability and its clinical relevance.
I am particularly interested in anatomical variation and the three-dimensional relationships between anatomical structures, with a focus on characterising and understanding individual differences in human anatomy.
Alongside my anatomical research, I have experience in quantitative movement analysis and biomechanical modelling, allowing me to approach complex anatomical questions from both structural and functional perspectives.