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Important macroscopic and microscopic differences in the bony and cartilaginous regions adjacent to the lumbar intervertebral disc between animal and man: a caveat to overinterpretation of animal experiments

Comment to the article: Primary stability of anterior lumbar stabilization: interdependence of implant type and endplate retention or removal (C.H. Flamme et al.)

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Point of view

The bovine, ovine, and porcine vertebral columns have recently gained popularity among researchers dealing with biomechanical and biological studies in the lumbar spine.

Usually, for experiments, Minipigs [4, 5], Landrace pigs, sheeps [3], or calves [8, 9] are utilized; pigs and sheep being rarely older than 2 years, the latter being mostly about 6 to 12 months old. This is mainly a matter of availability of these animals.

However, there is little awareness about fundamental differences between adult human and animal anatomy in the lumbar spine. Particularly the “endplate” region is a constant source of confusion.

Human anatomy and ontogenesis of functional spinal units (FSUs) are well described in the literature and need not be repeated here.

Besides the obvious differences in size and shape of the vertebral body, the orientation of the spinous and transverse processes, pointing upward in animals instead of downward or horizontally in man, are different, due to the different necessities of the quadruped. Thus, it is not surprising that the structures around the intervertebral disc are different, too. Also, Minipigs are known to have a retarded growth which renders them skeletally immature, even after adolescence. Even the macroscopic composition of the disc differs from humans, showing a pronounced separation of nucleus and annulus. These differences are again easy to detect in MRI and (partly) CT scans.

Thus, all these young quadrupeds are not a perfect model for lumbar endplate trauma in adolescents since the architecture of the endplate region lacks apophyseal structures and leaves the epiphyseal plate as a locus minoris resistentiae for shearing forces unconsidered.

Fig. 1 Bovine FSUs clearly showing the growth plates which are completely different from human apophyseal structures

For biomechanical studies, e.g., with application of cages, deliberate or inadvertent scraping of a “cartilaginous endplate” like in man the same holds true, whereas in humans the exposed cortical bone or the following

cancellous bone is in solid contact with the vertebral body, in these animals an unfused bony endplate is “riding” on the vertebral body (Fig. 1).

This may also have some impact on the nutrition of the disc and its adjacent structures since growth plates are physiologically very active structures. Yet, very little is known about the nutritional pathways of the animal’s FSU as compared to the human intervertebral space.

These limitations, which are also noticeable in several other species, must be borne in mind when transferring animal experiment results to the same situation in man. Their impact on the results may be unpredictable. Only adult primates, including Vervet [6] and Rhesus monkeys, overcome these limitations by showing a similar ossification pattern, and only larger primates such as baboons [7] additionally have comparable sizes of the FSUs like humans. At least simultaneously choosing further animals for experiments concerning the FSU, already including sheep [10, 11], dog, or, for their more bipedal characteristics even more exotic like kangaroo [1, 2], detailed information about these possible differences needs to be gathered and made public.

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