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# Magnetic resonance imaging of the levator ani in the squirrel monkey: A comparison of muscle volume between a cohort with pelvic organ prolapse and matched normals

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**KEY WORDS**
Magnetic resonance imaging
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**Objective:** Magnetic resonance imaging was used to test whether squirrel monkeys with pelvic organ prolapse have reduced pelvic muscle volumes, compared with matched normals.
**Study design:** Levator ani and obturator internus volumes obtained from T1-weighted axial scans of matched groups were measured. Muscle volumes and weights were compared for animals necropsied after magnetic resonance imaging.
**Results:** Two observers concurred on measures of levator ani and obturator internus (Kendal tau $\geq 0.60$ with $P < .003$). Levator ani volume was related to mass ($R^2 = 0.62$, $P = .0009$). Animals with pelvic organ prolapse did not differ ($P = .67$, Wilks multivariate test) from those without pelvic organ prolapse in age, parity, and weight. Levator ani differed between groups (pelvic organ prolapse = 520 $mm^3$ versus normals = 392 $mm^3$, $P = .015$) and not sides ($P = .80$). The obturator internus did not differ between groups ($P = .29$) or sides ($P = .72$).
**Conclusion:** Magnetic resonance imaging demonstrates that levator ani volumes in parous squirrel monkeys with pelvic organ prolapse were not reduced, suggesting that prolapse is not related to pelvic muscle size reduction in this species.


Pelvic organ prolapse (POP) affects 1 in 9 women over the course of a lifetime.[1] This complex condition is thought to be influenced by prior vaginal delivery as well as aging. POP significantly alters the lives of affected patients. Currently quantification of pelvic organ prolapse is limited to measurements made during a clinical examination using classifications such as the Pelvic Organ Prolapse Quantification[2] or the Baden-Walker halfway[3] systems. Magnetic resonance imaging (MRI) as a method for the assessment of POP is investigational at this time.

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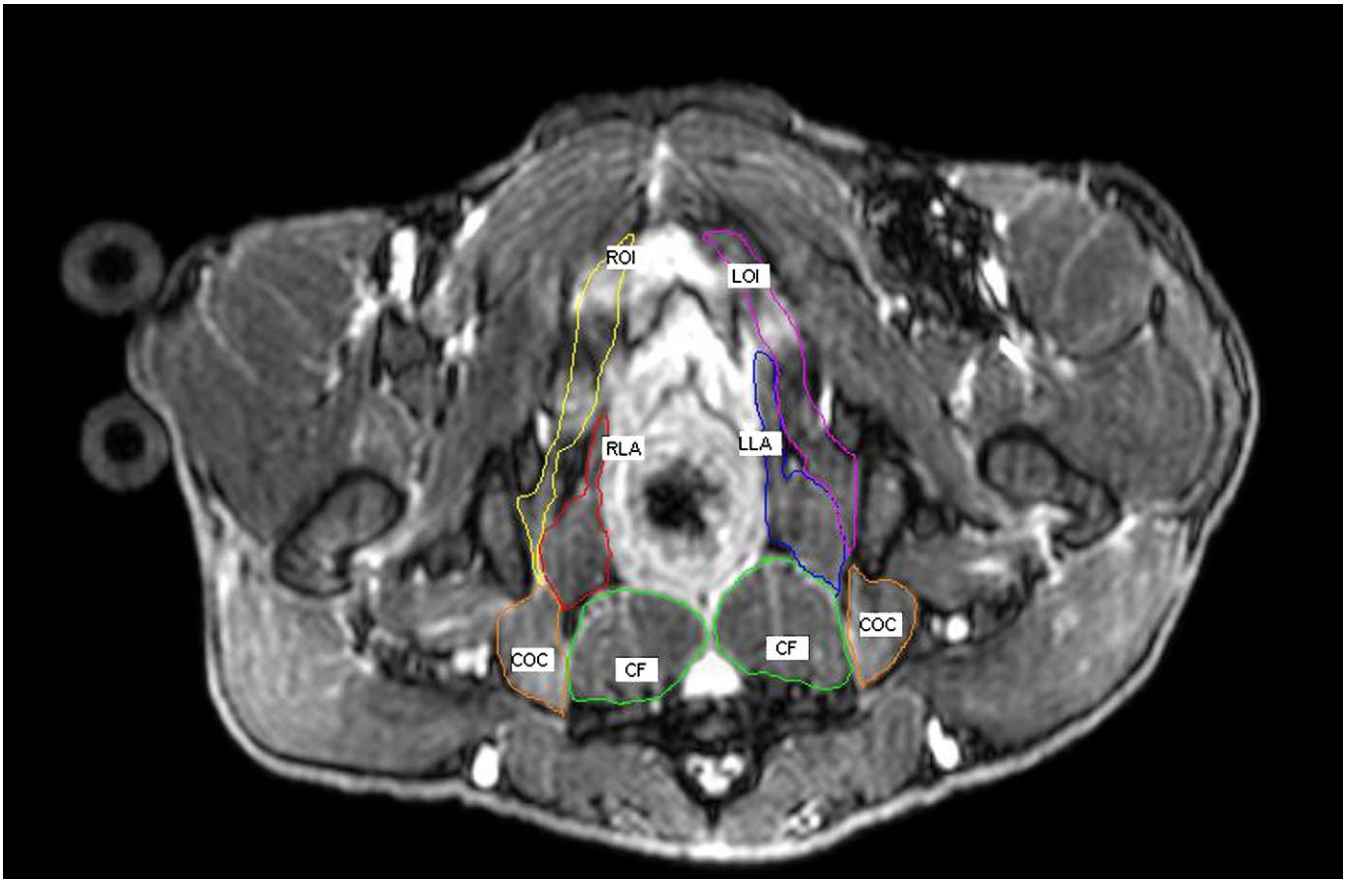


**Figure 1** Axial image from MRI sequence in multiparous female demonstrating muscles of the pelvic floor. *ROI,* Right obturator internus, *LOI,* left obturator internus, *RLA,* right levator ani, *LLA,* left levator ani, *COC,* coccygeus, *CF,* caudal flexor.

Both conventional 2-dimensional images and 3-dimensional modeling techniques have been studied in humans using multiple static and dynamic measurements to compare asymptomatic subjects with those experiencing prolapse or genuine stress incontinence symptoms.[4] Although Fielding et al[5] found levator ani volume to be relatively uniform among asymptomatic, nulliparous women, Tunn et al[6] concluded that considerable variation in levator ani (LA) volume exists in this same group. Hoyte et al[4] found differences in position and shape of LA muscles in patients with prolapse versus those without during dynamic maneuvers (maximum Valsalva) as well as static imaging. Methods of measurement, the range of normal variation, and relative position of abdominal structures with and without straining need to be established before MRI can become a useful clinical tool for the assessment of POP. However, the potential of MRI as a noninvasive means of evaluating POP is immense.

## Squirrel monkey animal model of pelvic organ prolapse

We have demonstrated the presence of pelvic support defects in 50% of older female squirrel monkeys.[7] These defects are associated with childbirth and aging.[8] Therefore, the squirrel monkey may represent an animal model for the study of POP. We have begun to study MRI in this model.

In humans, numerous static and dynamic MRI measures of various distances and angles between pelvic structures have been reported.[4-6,9,10] However, because of its smaller size and the differing anatomy of the bony pelvis to include a tail rather than coccyx, these measurements may be difficult to obtain or interpret in the squirrel monkey. Levator ani volumes have also been measured and shown to differ among patients serving as controls, those with genuine stress incontinence, and those with prolapse who were comparable in age, parity, and body mass index.[4] For these reasons, our initial trial focused on volume measurements.

Pelvic organ prolapse is thought to result from a defect in muscle and/or connective tissue support. We hypothesized that muscle wasting and weakness may influence POP and that animals with visible pelvic floor defects will have reduced muscle mass of pelvic floor muscles, compared with matched normals. These changes in muscle mass may be quantified using measurements of muscle volume obtained from 3-dimensional models. We had a cohort of 7 older, parous female squirrel monkeys