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MEASURING THE PUBOCOCCYGEAL LINE FROM MAGNETIC RESONANCE IMAGES: COMPARISON OF TWO METHODS

Hypothesis / aims of study
The pubococcygeal line (PCL) is one of the primary landmarks used to assess pelvic support from sagittal magnetic resonance images (MRIs). Currently, there is no consensus in the literature about which posterior anatomical landmark to use as the end of the PCL (1, 2). Various authors have placed the posterior end on the tip of the coccyx, on the last joint of the coccyx or on the sacrococcygeal joint. With respect to placing the posterior end on the tip of the coccyx, we were concerned that movement of the coccyx, produced by pelvic floor muscle (PFM) contraction and Valsalva, would affect the length and position of the PCL; in effect, rendering comparisons of pelvic organ support between conditions of rest, PFM contraction and Valsalva less valid.
Therefore, the purpose of this study was to compare the length of the PCL, measured to two posterior ends: the tip of the coccyx (PCLtip) and the sacrococcygeal joint (PCLjnt), under three conditions: rest, PFM maximum voluntary contraction (MVC) and Valsalva, to determine which of the PCLs provides the most reliable baseline for measures of pelvic organ support.
Study design, materials and methods
Women 60 years and older were recruited and included in the study if they were ambulatory and were either continent or reported at least weekly symptoms of mixed or stress urinary incontinence (MUI or SUI). Women were excluded if they reported contraindications to MRI scanning, or if they reported other conditions or were taking medications known to interfere with the study. An experienced pelvic floor physiotherapist taught the women to perform PFM contractions correctly. MRI imaging in the sagittal plane was performed with a Siemens 3.0T Magnetom Trio, using an IPAT torso/pelvis coil centered at the symphysis pubis. Six slices were recorded with T2 weighted SSFSE sequences (field of view 24 x 24 cm, 5 mm thick, matrix of 256 x 256, TR 3000 ms, TE 110 ms, bandwidth 320 Hz/pixel). During the scan, 18 s recordings were made at rest, during a PFM MVC and during a Valsalva manoeuvre.
The measurements at rest were taken from the mid-sagittal slice. For the PFM MVC and the Valsalva images, the measurements were made from the slices that demonstrated the most bladder neck elevation and depression respectively. The PCLtip was drawn from the inferior edge of the pubic symphysis to the tip of the coccyx and the PCLjnt was drawn from the inferior edge of the pubis symphysis to the anterior aspect of the sacrococcygeal joint (See Figure 1). The PCLtip was measured first and then erased prior to measuring the PCLjnt.
The lengths of the lines under the three conditions were compared using a two-way repeated measures analysis of variance. The line by condition interaction was included in the model. Post hoc comparisons were made using the Bonferroni method to correct for multiple comparisons.
Results
Forty-seven women participated: 14 continent, 24 with MUI and nine with SUI. Their mean age was 67.6 (SD 4.7) years, mean parity was 1.7 (SD 1.5) births and they had a mean body mass index (BMI) of 25.5 (SD 3.9) kg/m^2.
The PCLjnt was longer than the PCLtip in all three conditions ($p<0.001$). The line by condition interaction was significant ($p=0.027$, $\beta=0.675$); the PCLjnt length did not change among the three conditions, while the PCLtip shortened during the PFM MVC. However, the shortening effect was small making the post hoc comparisons non significant (See Figure 2).
The analyses were repeated with the 34 cases (72%) who demonstrated at least a 1mm difference in PCLtip length between rest and either PFM MVC or Valsalva. These women were not significantly different in age, parity or BMI from the participants as a whole. In these analyses, the line by condition interaction was again significant ($p<0.001$, $\beta=0.999$) and the same shortening pattern was demonstrated. In the post hoc analyses, the PCLtip was shorter during the PFM MVC than it was at rest or during Valsalva ($p<0.001$ and $p=0.003$, respectively), and there was no difference in the length of PCLtip between rest and Valsalva ($p=0.89$). Again, there was no change in the length of the PCLjnt with any of the manoeuvres ($p>0.84$ for all comparisons) in the subgroup.
Interpretation of results
Our results confirm the findings of Bø et al. (3) that PFM contractions produce movement of the coccyx. They are novel in that they not only demonstrate this movement in older women but they also measure the effect of this movement on a commonly used parameter for assessing pelvic organ support. These findings suggest that the tip of the coccyx should not be used as the posterior landmark for the PCL, because movement of the coccyx results in changes in the length and the position of the line. If the PCLtip is used as the reference line for measuring pelvic organ support during PFM MVC and Valsalva, the movement of the line may result in errors in other measurements.
Unlike the findings of Bø et al. (3) there was no difference in the mean length of the PCLtip between rest and Valsalva. This is because some women demonstrated lengthening of the PCLtip while other demonstrated shortening, likely because they were contracting their PFMs during the Valsalva manoeuvre. Future research should specifically instruct women to relax their PFMs during Valsalva manoeuvres.
Thirteen (28%) of the women did not produce any movement of the coccyx during either the PFM MVC or the Valsalva. As movement of the pelvic organs was visible during the tasks in these women, it is unlikely that the lack of coccyx movement was due to either an inability to perform the contraction or a lack of effort during the Valsalva. More probably, the coccygeal joints were immobile in these women or, alternatively, the supine position prevented movement of the coccyx.
Concluding message
A substantial majority of the older women in this study (72%) demonstrated movement of the coccyx during PFM MVCs and Valsalva manoeuvres, therefore the PCL should be drawn from the inferior edge of the pubic symphysis to the sacrococcygeal joint and not to the tip of the coccyx to avoid introducing error into measures of pelvic organ support.

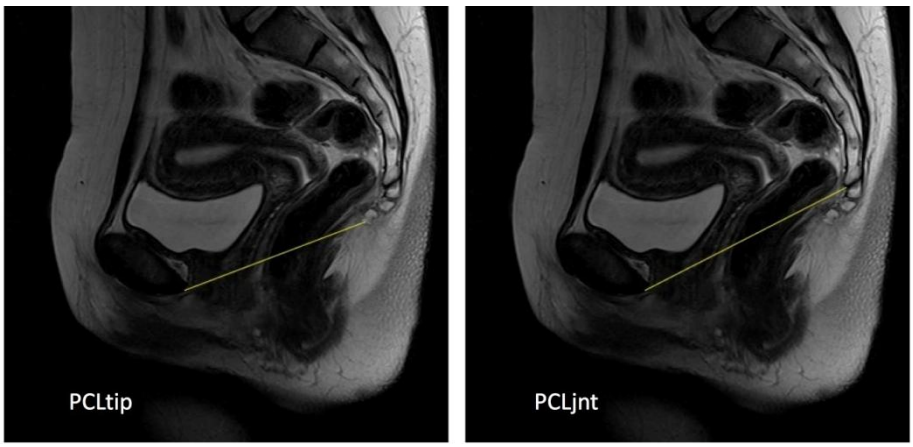

Figure 1. Pubococcygeal lines. PCLtip: to the tip of the coccyx. PCLjnt: to the sacrococcygeal joint line.

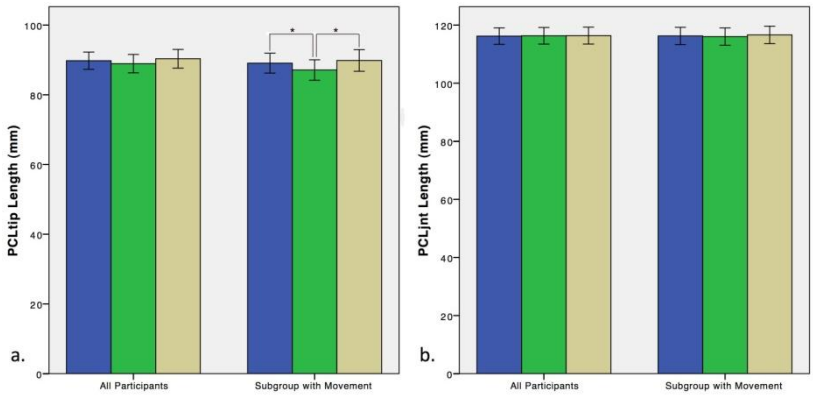

Figure 2. Length of the pubococcygeal lines (PCL) in the three conditions: a. PCL to the tip of the coccyx, b. PCL to the sacrococcygeal joint. Blue: Rest, Green: PFM MVC and Beige: Valsalva. All Participants: all subjects included and Subgroup with Movement: only subjects who demonstrated coccyx movement (34 of 47) included. * indicates p<0.005.

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Specify source of funding or grant	**Fonds de recherche en santé du Québec, Axe Incontinence urinaire, Réseau québécois de recherche sur le vieillissement du Fonds de recherche en santé du Québec, and Canadian Institutes of Health Research**
Is this a clinical trial?	**No**
What were the subjects in the study?	**HUMAN**
Was this study approved by an ethics committee?	**Yes**
Specify Name of Ethics Committee	**Comité mixte d'éthique de la recherche - Regroupement Neuroimagerie Québec**
Was the Declaration of Helsinki followed?	**Yes**
Was informed consent obtained from the patients?	**Yes**