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URETHRAL MOBILITY AND ITS RELATIONSHIP WITH URODYNAMIC DIAGNOSIS

<u>Hypothesis / aims of study</u>
While bladder neck mobility has been a focus of clinical practice and research for half a century, to date there is no data on urethral mobility in patients with lower urinary tract symptoms. Urethral mobility is likely to be of crucial importance in the pathophysiology of urinary incontinence, in particular stress incontinence (SI), because of the issue of pressure transmission. Clearly, pressure transmission requires force acting on certain segments of the urethra, and this implies limitation of movement which should be detectable on modern imaging. We have recently developed a methodology to quantify segmental urethral mobility, obtaining a 'urethral motion profile (UMP)'(1). To investigate the relationship between urethral mobility and urinary incontinence we determined the UMP in patients attending for multichannel urodynamics.

<u>Study design, materials and methods</u>
Between December 2006 and July 2008, a total of 305 women attended a tertiary referral service for multichannel urodynamic testing (Neomedix Acquidata) and 4D pelvic floor ultrasound imaging (GE Kretz Voluson 730 expert) (2). Of those, 79 patients were excluded due to previous anti- incontinence or prolapse surgery, leaving 226 urodynamic datasets. In 28 cases, ultrasound volume data was either unavailable due to clerical error or data corruption or was technically inadequate for UMP determination, leaving 198 patients with complete datasets. All subsequent analysis was performed in this group. UMP analysis was carried out by the first author, at least 5 months after the clinical appointment and blinded against all clinical data, using the software 4D View on a desktop PC. The urethral length was traced and divided into 5 segments by defining 6 equidistant points along its length, with Point 1 at the internal urethral meatus, and Point 6 at the external meatus (see Figure 1). As the manual determination of UMP coordinates is very time- consuming, we developed a semi-automatic method utilizing an Excel macro, allowing automatic determination of x and y coordinates on a bitmap imported from 4D View. UMP results were tested against symptoms, urodynamic results and diagnoses. In a subgroup, multivariate analysis was carried out to account for the confounding effect of maximum urethral closure pressure.

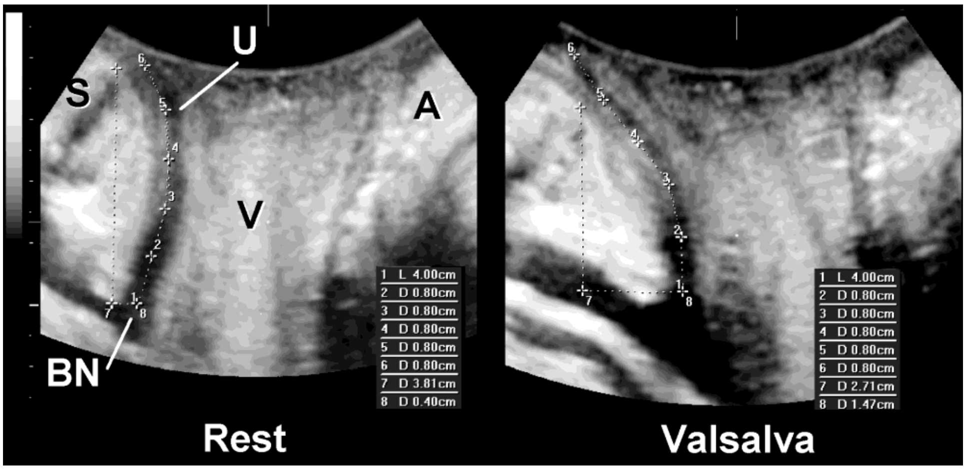

Fig 1: Determination of segmental urethral mobility. U= urethra, V= vagina, S= symphysis, BN= bladder neck, A= anal canal. The total urethral length is divided into 5 equal segments, and the location of the six resulting points is measured relative to the inferoposterior symphyseal margin.

<u>Results</u>
A test-retest series of 10 UMPs (60 mobility vectors) performed by the first and second authors showed good to excellent repeatability, with an Intraclass correlation of 0.925 (CI 0.878- 0.925) for segmental urethral mobility. All data was normally distributed unless otherwise indicated. The mean age of the 198 patients with complete datasets was 53.7 (range, 19-85). They presented with stress incontinence (n=160, 81%), urge incontinence (n=144, 73%), Frequency (n= 68, 34%), Nocturia (n=90, 46%), symptoms of voiding dysfunction such as hesitancy, poor stream, stop- start voiding (n=45, 23%) and symptoms of prolapse (vaginal lump or dragging sensation (n= 77, 39%). 182 had delivered vaginally (92%), and 25% (n=50) had previously undergone a hysterectomy for indications other than prolapse. The mean bladder neck descent was 32.1 mm. On clinical assessment, 58% (n=115) had a significant (ICS POP-Q Grade 2 or higher) prolapse. This was a cystocele in 46% (n= 91), a uterine prolapse in 8% (n=12), an enterocele in 6% (n=12) and a rectocele in 34% (n=67). Levator avulsion was diagnosed in 18% (n= 35).
In two cases urodynamic testing was not completed due to urethral stenosis in one case and compliance issues in another, leaving 196 urodynamic datasets. We diagnosed Urodynamic stress incontinence (USI) in 68% (n=133), Detrusor Overactivity (DO) in 24% (n= 47) and voiding dysfunction (VD) in 26% (n= 51). The latter was defined as an abnormal pressure flow study and/ or a residual of over 50 mls on free flowmetry, and/ or a maximum flow rate centile under the 10^{th} centile of the Liverpool nomogram (3). Free flowmetry was obtained for 163 patients. The mean voided volume was 264 ml, and the mean maximum flow rate centile was 33.5 (range, 0 to 98). The median residual was 0 (interquartile range, 0 to 20).
All ultrasound data used in this analysis was normally distributed. The vectors were measured at a mean of 2.95, 2.56, 2.22, 1.96, 1.83 and 1.87, demonstrating that the distal urethra generally is less mobile than the proximal urethra. The degree of mobility was associated with SI, especially for the central urethra (Point 2, P= 0.014, Point 3, P= 0.006, Point 4, P= 0.021). This relationship did not reach significance for the points 1, 5 and 6, i.e., for the most proximal and distal aspects of the organ. There was no relationship between urethral mobility and urge incontinence or symptoms of voiding dysfunction. As regards urethral mobility and the diagnosis of USI, again we saw the strongest relationship for points 2 to 4 (all P< 0.001), but points 1,5 and 6 also reached significance in that USI patients generally had higher urethral mobility than those without USI. MUCP did not act as a confounder in the relationship

between urethral mobility and SI or USI. There was no relationship between DO or urodynamically diagnosed VD and urethral mobility.

Point	**SI (yes, n=160; no=38)**	**USI (yes, n=133; no, n=63)**
Point 1 (bladder neck)	3.01 (SD 1.04) vs 2.69 (SD 1.05) P= 0.09	3.14 (SD 0.98) vs. 2.56 (SD 1.09) **P= 0.001**
Point 2	2.63 (SD 0.88) vs. 2.25 (SD 0.82) **P= 0.014**	2.72 (SD 0.88) vs. 2.20 (SD 0.88) **P< 0.001**
Point 3	2.29 (SD 0.73) vs. 1.94 (0.67) **P= 0.006**	2.36 (SD 0.68) vs. 1.93 (SD 0.73) **P< 0.001**
Point 4	2.0 (SD 0.63) vs. 1.75 (SD 0.59) **P= 0.021**	2.07 (SD 0.6) vs. 1.73 (SD 0.62) **P< 0.001**
Point 5	1.86 (SD 0.61) vs. 1.70 (SD 0.58) P= 0.12	1.93 (SD 0.59) vs. 1.64 (SD0.60) **P= 0.002**
Point 6 (Internal meatus)	1.89 (SD 0.66) vs. 1.76 (SD 0.65) P= 0.26	1.95 (SD 0.64) vs. 1.70 (SD 0.67) **P= 0.016**

Table 1: Relationship between avulsion defects and segmental urethral mobility (n= 198).

Interpretation of results
In this study combining multichannel urodynamics and ultrasound assessment of segmental urethral mobility we were able to show that the symptom of SI and the diagnosis of USI are associated with increased urethral mobility, especially of the central urethra. This relationship was highly significant. It is hypothesized that this association reflects an impairment of urethral fixation and therefore pressure transmission.

Concluding message
There is a significant association between central urethral mobility and stress urinary incontinence as well as urodynamic stress incontinence.

References
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What were the subjects in the study?	**HUMAN**
Was this study approved by an ethics committee?	**Yes**
Specify Name of Ethics Committee	**SWAHS HREC**
Was the Declaration of Helsinki followed?	**Yes**
Was informed consent obtained from the patients?	**No**