A modified Edinburgh Pipe Phantom to quantify the effect of slice thickness on the imaging performance of curvilinear probes

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INTRODUCTION AND BACKGROUND

- The **Edinburgh Pipe Phantom (EPP)** is an agar-based phantom incorporating anechoic fluid-filled pipes embedded at 40^0 to the vertical. The EPP is used to measure a dimensionless parameter known as the **resolution integral (R)** which is a figure of merit that characterises the ratio of penetration to resolution of ultrasound scanner/transducers.
- We have previously shown that the EPP is capable of measuring the performance of both clinical and preclinical ultrasound probes over 2.5-55MHz range[1].
- Recently we have demonstrated the impact of slice thickness on *linear and matrix arrays* and shown that R increases by a factor greater than 2.5 when slice thickness effects were removed[2].
- Curvilinear arrays also have poor resolution in the slice thickness plane (elevation plane)

Resolution Integral (R)

Dimensionless figure of merit (*R*) for **performance assessment** of medical ultrasound probes; accompanied by **characteristic resolution D_R and depth of field L_R** where L_R is defined as the region of best imaging and D_R is the typical lateral resolution within the depth of field.

$$R = \int_0^\infty L \, d\alpha$$

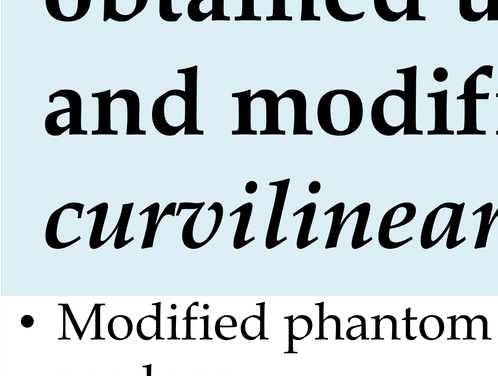
Where L is the depth range over which an object of diameter $1/\alpha$ can be resolved

AIM

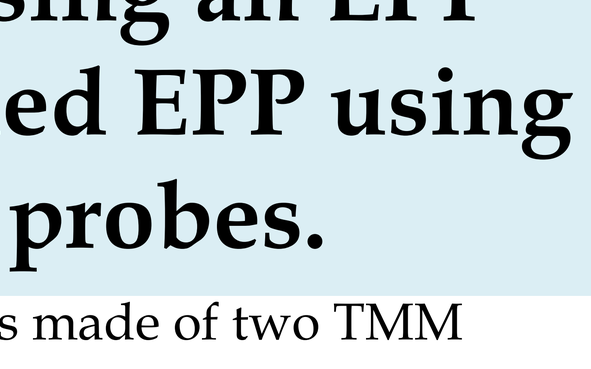
Compare *R* values obtained using an EPP and modified EPP using *curvilinear* probes.

MEHODS

- Modified phantom is made of two TMM wedges
- Slice thickness effects will be eliminated as width of the wedges is significantly greater than slice thickness.
- Five slot-widths achieved (0.42-2.5mm) by separation of the wedges using strips of polypropylene of varying width.
- Two curvilinear probes were tested – Siemens S2000 6C1 HD (1-6MHz) and 4C1 (1-4MHz).



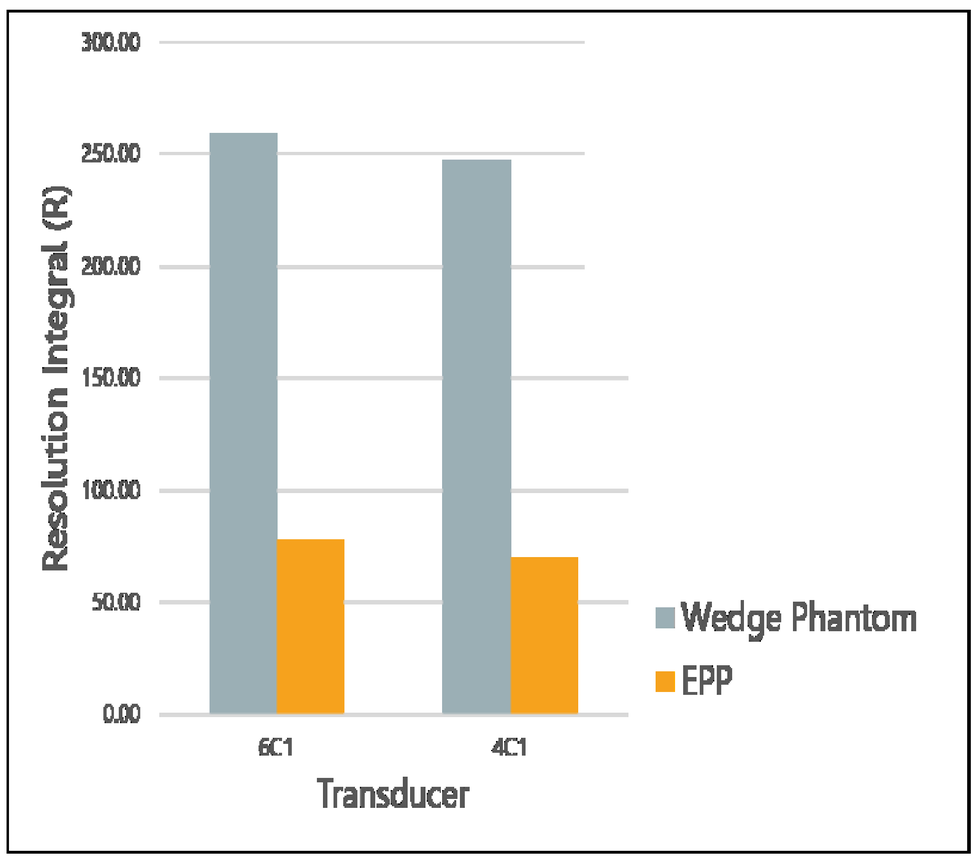
Side View



Top View

RESULTS

Resolution integrals for two curvilinear probes



EPP – includes effects of slice thickness
New wedge phantom – excludes effects of slice thickness

Using novel wedge phantom to eliminate slice thickness effects results in:

- **increases in *R*** by factors more than 3
- **improvements in D_R** by factors more than 3
- no significant changes in depth of field

DISCUSSION

- New design of phantom allows measurement of *R* using curvilinear probes without slice thickness effects
- Highlights the need for continued use of phantoms such as EPP that test slice thickness
- Highlights the need for improved transducer design to achieve better elevational focusing to avoid missed findings of small cysts and lesions.

CONCLUSION

Poor slice thickness in curvilinear probes translates to substantially reduced performance in imaging anechoic structures.

References
[1]Moran CM et al. The Imaging Performance of Diagnostic Ultrasound Scanners Using the Edinburgh Pipe Phantom to Measure the Resolution Integral – 15 Years Experience. Ultraschall in der Medizin 2022;43:393-402
[2]Carstairs H. et al. A novel ultrasound phantom to quantify the effect of slice thickness on imaging performance. 2019 IEEE Ultrasonics Symposium 2404-2407.

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