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Corrigendum: Measurement of guided mode wavenumbers in soft tissue–bone mimicking phantoms using ultrasonic axial transmission


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The following corrections should be taken into account:

(1) The sentence ‘where the sign $\pm$ indicates the positive and negative ($Ox_3$) directions (figure 1)’ after equation (2) should be:

‘where the sign $+$ relates to the quasi-shear (QS) wave. Likewise, the sign $-$ relates to the quasi-longitudinal (QL) wave. The index 1 and 3 relates to the axis ($Ox_1$) and axis ($Ox_3$) shown in figure 1.’

(2) The second term of equation (3a) $C_{33}C_{55}$ should be $2C_{13}C_{55}$.

(3) In equations (4a) and (4b) the plate thickness term $h$ should be corrected as the half plate thickness $h/2$. The following sentence ‘with $h$ the plate thickness (figure 1)’ should be added after equation (4a).

Secondly, consider a free transverse isotropic elastic plate of thickness $h$ (figure 1). The direction ($Ox_1$) is the symmetry axis. Guided waves in the elastic plate are different from their counterparts in the fluid layer as the elastic plate supports the propagation of shear waves. Because the probe works in piston mode and does not excite horizontal shear displacement, only motion in the plane ($Ox_1x_3$) is considered. Thus a two dimensional approximation can be considered (Dayal and Kinra 1989, Rhee et al 2007). Following previous conditions, the relation between $k_3$ and $k_1$ satisfies (Dayal and Kinra 1989, Rhee et al 2007)

$$k_{3_{\pm}}^2 = \left( -M \pm \sqrt{M^2 - 4N} \right)^2 k_1^2,$$

(2)

where the sign $\pm$ indicates the positive and negative ($Ox_3$) directions (figure 1). The terms $M$ and $N$ correspond to

$$M = \frac{C_{11}C_{33} - C_{33}C_{55} - C_{13}^2 - \frac{\rho \omega^2}{k_1^2} (C_{33} + C_{55})}{C_{33}C_{55}},$$

(3a)
where \( \rho \) is the plate density, \( \omega \) is the angular frequency, and \( C_{11}, C_{33}, C_{13} \) and \( C_{55} \) are the stiffness coefficients of the transverse isotropic plate. Following equation (32) of reference (Rhee et al. 2007), the dispersion equation of the symmetric Lamb modes \( S_n \) can be written as

\[
(C_{33}R_- k_{3-} + C_{13}k_1)(R_+ k_1 + k_{3+}) \sin(k_{3+}h) \cos(k_{3-}h) \\
-(C_{33}R_+ k_{3+} + C_{13}k_1)(R_- k_1 + k_{3-}) \sin(k_{3-}h) \cos(k_{3+}h) = 0, \tag{4a}
\]

Following equation (34) of reference (Rhee et al. 2007), the dispersion equation for the anti-symmetric modes \( A_n \) is obtained by inverting the + and − subscripts inside the parentheses in (4a)

\[
(C_{33}R_+ k_{3+} + C_{13}k_1)(R_- k_1 + k_{3-}) \sin(k_{3-}h) \cos(k_{3+}h) \\
-(C_{33}R_- k_{3-} + C_{13}k_1)(R_+ k_1 + k_{3+}) \sin(k_{3+}h) \cos(k_{3-}h) = 0, \tag{4b}
\]

The corrected version of page 3028 should be:

Secondly, consider a free transverse isotropic elastic plate of thickness \( h \) (figure 1). The direction \((Ox_3)\) is the symmetry axis. Guided waves in the elastic plate are different from their counterparts in the fluid layer as the elastic plate supports the propagation of shear waves. Because the probe works in piston mode and does not excite horizontal shear displacement, only motion in the plane \((Ox_1x_3)\) is considered. Thus a two dimensional approximation can be considered (Dayal and Kinra 1989, Rhee et al. 2007). Following previous conditions, the relation between \( k_3 \) and \( k_1 \) satisfies (Dayal and Kinra 1989, Rhee et al. 2007)

\[
k_{3\pm}^2 = \left( -M \pm \sqrt{M^2 - 4N} \right)^2 k_1^2, \tag{2}
\]

where the sign + relates to the quasi-shear (QS) wave. Likewise, the sign − relates to the quasi-longitudinal (QL) wave. The index 1 and 3 relates to the axis \((Ox_1)\) and axis \((Ox_3)\) shown in figure 1. The terms \( M \) and \( N \) correspond to

\[
M = \frac{C_{11}C_{33} - 2C_{33}C_{55} - C_{13}^2 - \frac{\rho \omega^2}{k_1^2} (C_{33} + C_{55})}{C_{33}C_{55}}, \tag{3a}
\]

\[
N = \frac{\left( \frac{\rho \omega^2}{k_1^2} - C_{11} \right) \left( \frac{\rho \omega^2}{k_1^2} - C_{55} \right)}{C_{33}C_{55}}, \tag{3b}
\]

where \( \rho \) is the plate density, \( \omega \) is the angular frequency, and \( C_{11}, C_{33}, C_{13} \) and \( C_{55} \) are the stiffness coefficients of the transverse isotropic plate. Following equation (32) of Rhee et al. (2007), the dispersion equation of the symmetric Lamb modes \( S_n \) can be written as

\[
(C_{33}R_- k_{3-} + C_{13}k_1)(R_+ k_1 + k_{3+}) \sin(k_{3+}h/2) \cos(k_{3-}h/2) \\
-(C_{33}R_+ k_{3+} + C_{13}k_1)(R_- k_1 + k_{3-}) \sin(k_{3-}h/2) \cos(k_{3+}h/2) = 0, \tag{4a}
\]

with \( h \) the plate thickness (figure 1). Following equation (34) of Rhee et al. (2007), the dispersion equation for the anti-symmetric modes \( A_n \) is obtained by inverting the + and − subscripts inside the parentheses in (4a):

\[
(C_{33}R_+ k_{3+} + C_{13}k_1)(R_- k_1 + k_{3-}) \sin(k_{3-}h/2) \cos(k_{3+}h/2) \\
-(C_{33}R_- k_{3-} + C_{13}k_1)(R_+ k_1 + k_{3+}) \sin(k_{3+}h/2) \cos(k_{3-}h/2) = 0. \tag{4b}
\]
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