Purpose: In this study, we have developed an explicit analytical model to compute the effective depth of cylindrical ionization chambers in water for clinical proton beams. We have compared our explicit analytical model with an existing series expansion model. We have calculated the shift of water equivalent depth for different cylindrical ionization chambers and have compared our results with the IAEA recommendations and series expansion model.

Methods: We have developed a method to compute the elliptic integral in an explicit analytical form. Using this integral form, the shift of water equivalent depth has been computed by accounting for individual contributions of ionization chamber cavity, wall, central electrode and sleeve for proton energies ranging from 1.0 Kev to 1.0 Gev for thirty four commercially available ionization chambers.

Results: The comparison of explicit analytical expression with series expansion reveals that integrations calculated by series expansion fail to converge when the ratio of radii of cylindrical ionization chambers is greater than 0.5. For all the ion chambers selected in this study, our results vary at maximum of 0.5 mm from the IAEA recommendations, whereas the maximum variation for the series expansion model is 1.5 mm.

Conclusions: The findings of this study suggest that the developed analytical model is reliable for calculation of the effective depth in water. Further, verification of these results with Monte Carlo calculation may suggest the need for review of the standards for all commercial ionization chambers.