Purpose: To extend a previously described technique of modeling 2-D fluence from any MLC leaf sequence, and develop an independent and accurate calculation of modulation factors required for pre-treatment QA of IMRT plans. This calculation is intended to replace ion chamber measurements and thus offers a quicker and more streamlined verification process.

Methods: In-house software developed in MATLAB was used to calculate each IMRT field’s modulation factor, defined as the ratio of the dose with MLC to the corresponding open field dose (without MLC) at a given reference point. For IMRT fields, the program uses the leaf sequence file for each dynamic field to calculate 2-D maps of the primary fluence modulation and the timings of leaf openings. Fluence modeling includes beam horn characterization and head scatter effects. Commissioning values of leaf transmission and the dynamic leaf gap for our Varian Millenium MLCs are used to incorporate the effects of transmission and rounded leaf-end design on the fluence modulation. Interleaf leakage and tongue-and-groove effects are modeled based on the timing map and the shape (including penumbra) of the interleaf leakage and tongue-and-groove characterized from 2-D EPID images. Once calculated, the IMRT fluence is convolved with a Monte-Carlo (EGSnrcMP) pencil-beam kernel to generate a dose at the reference point depth, and divided by the open field dose to obtain the calculated modulation factor.

Results: Results from 18 IMRT plans (121 fields), including treatments from pelvis, prostate, head and neck, and anal canal cancer, show excellent agreement between calculated and ion-chamber measured modulation factors. The mean discrepancy is -0.3%, with standard deviation of 1.2%, where calculation times are 55 seconds per field on one PC core.

Conclusions: An accurate and streamlined calculation method for determining modulation factors has been developed to replace tedious ion chamber measurements needed for pre-treatment IMRT QA.