Purpose: The latest Gamma Knife (GK) system, Perfexion, consists of 192 Co-60 sources divided into eight sectors. Treatment delivery includes multiple shots placed at different positions. For every shot, each sector can be either blocked or open with four different aperture sizes. However, the beam-on time is designed to be fixed. We proposed an innovative concept, Sector Intensity Modulated (SIM) Gamma Knife by dynamically varying the beam-on time for each individual sector to improve stereotactic radiosurgery planning quality.

Methods: The anatomic structures and dose matrices from each sector for every shot were obtained from the GK workstation. The beam-on time for each sector was decomposed with various discrete levels and brute-force algorithm was used to get the optimal solution. The resulting SIM plan was then re-entered into the GK workstation. Six indices were used to benchmark the plan quality: Coverage, Conformality, Gradient, Maximum Dose(s) to critical structure(s), Volume receiving over 8 and 12 Gy. All the SIM plans in comparison with the original plans were further reviewed by an experienced oncologist.

Results: The simulations were tested on various pituitary adenoma cases. Results consistently showed that SIM yielded better plans with all quantitative indices improved compared to original plan. It provides better conformality, quicker drop off of the isodose line outside the tumor, lower doses to the critical structures as optical-nerve/chiasm while maintaining at least 99% coverage of the tumor. Results were more favorable according to oncologist's view. In particular, up to 20% or 0.6 cc volume decrease in healthy tissue receiving 8 Gy was observed. This may translate into clinically observable reduction in acute/late toxicities.

Conclusions: Our preliminary results show that Sector Intensity Modulated Gamma Knife offers superior treatment plans compared to the originally delivered plans. Further works as adding dynamic shot location and dynamic shot shaping will be discussed.