Optimal Airgap Selection and Enhanced Snout Collision Avoidance for Proton Therapy

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PURPOSE / OBJECTIVES

Proton planning systems have a safety feature for collision avoidance of predefined couch insert, simulated patient volume, and a safe zone (Figure 1a). However, Eclipse only detects collision within the maximum field size which is much smaller than the snout enclosure. As shown in Figure 1b for a Varian ProBeam 360° proton system, the snout enclosure is about 57cm x 39cm in dimensions while Eclipse only calculate and check the airgap under ~25cm x25cm, which is the max field size for a ProBeam 360°.

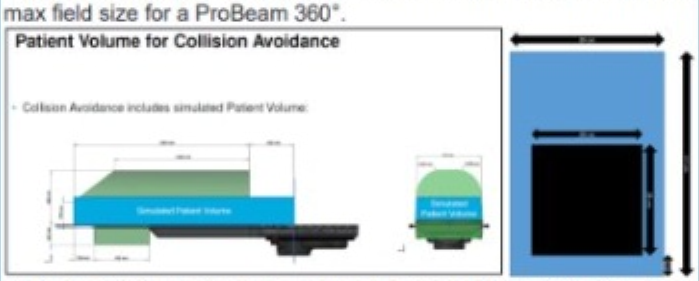

Figure 1a Collision Avoidance model for ProBeam360°. Figure 1b, Snout surface dimensions for ProBeam360°.

As a result, potential collision between snout and patient or couch may not be visualized in Eclipse and cause treatment delay when detected during patient setup. This study aims to customize a novel Eclipse-Scripting-API (ESAPI) based visualization tool to guide airgap or snout position selection and minimize treatment interruption by detecting collision during planning and chart check.

MATERIAL & METHODS

For proton treatment, snout is extended when range shifter is used, which will cause more potential collisions. The airgap is defined as the shortest distance between body structure and snout surface, not just under the maximum field size. Figure 2 shows Eclipse calculate the airgap under the max field size on the central axis, which is not accurate. The first goal of the script is to determine the correct airgap and thus detect collisions before setting up patient on couch.

Figure 2, the collision between snout and patient not detected by Eclipse.

MATERIAL & METHODS

Additionally, CT scans with limited field of view normally exclude parts of the couch or patient anatomy away from the isocenter. For example, the Qfix medium BoS insert is used for brain and head neck treatment as shown in Figure 3a. The couch base is often excluded from the imaging set (Figure 3b) and resulting in in accurate airgap or collision issue.

The second goal of the script is to create a custom snout model and expend patient body structure to include the couch base beyond CT scan range. The script displays 3D view of the snout and patient, allows snout position selection, and calculates the corresponding airgap between the most protruding point of patient body contour and the snout assembly.

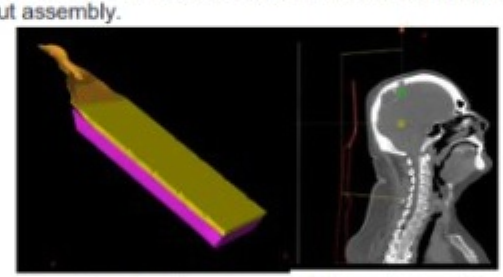

Figure 3a,Qfix medium BoS insert on top of the proton couch base (magenta color) and Figure 3b shows the limited CT image set excluding the couch base.

RESULTS

Collisions were detected by the script for various cases and different treatment sites, which were deemed cleared by Eclipse.

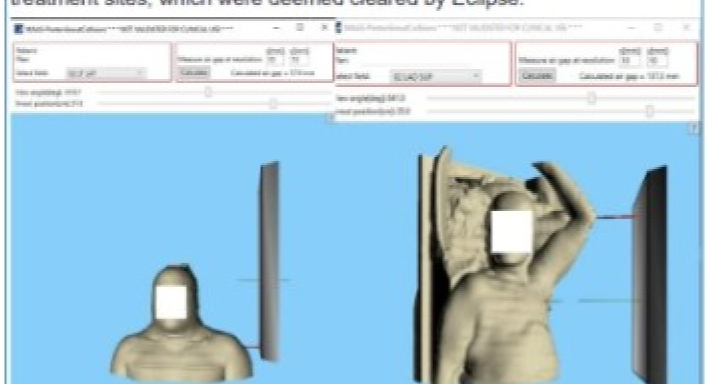

Figure 4a shows the script was able to detect a potential collision for a brain case (shoulder) and a chest wall case (elbow), which may be deemed cleared by Eclipse.

RESULTS

Particularly, collisions with couch were detected for cases with limited longitudinal CT scan length. The script is able to create and insert the couch base into the limited CT scan. These collisions were confirmed with dry-run and no treatments were interrupted.

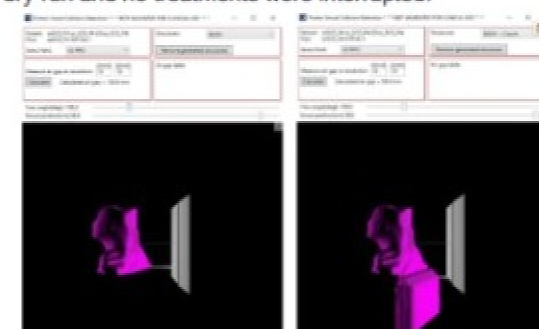

Figure 5, the script was able to insert the couch base structure, calculate the accurate air gap from body structure to the couch base and prevent collisions.

DISCUSSIONS

The novel script does not only provided an accurate airgap calculation, but is also able to insert the couch base to prevent setup issues on the treatment couch for both IBA and Varian proton systems.

However, the script is still limited by the field of view in the CT scan and won't detect any collision if the interested structure is not present in the CT scans, except the couch base. A new version is being worked to potentially generate other structures such as elbows.

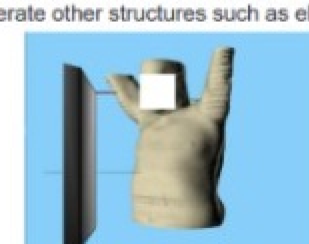

Figure 6, the script won't detect the elbows since they are not in the CT scan.

SUMMARY / CONCLUSION

The ESAPI script is initially developed for physics to check collision issue during initial chart check. But now it is used more often to guide the selection of optimal airgap before the treatment planning starts. It improved treatment planning and physics chart check efficiency and also enhanced treatment delivery safety.