Effects of Rigid Fixation Device Composition on Three-Dimensional Computed Axial Tomography Imaging: Direct Measurements on a Pig Model

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Objective: To compare the amount of scatter produced by titanium plates versus Vitallium (Howmedica, Rutherford, NJ) plates. Software was also evaluated to determine its effectiveness in removing the scatter and clarifying the underlying anatomy.

Materials and Methods: Miniplates and microplates systems composed of Vitallium or titanium were placed on the nasal and frontal bones of three adult pig heads. A computerized axial tomography (CAT) scan was then performed and a three-dimensional CAT scan was reconstructed using MediCad software (MediCad Inc, Cedar Knolls, NJ). The amount of scatter for each plating system was quantitated using the MediCad software measuring tool. The scatter was removed and the three-dimensional CAT scan was reconstructed to assess the clarification of the underlying anatomy.

Results: No scatter was found with either the miniplates or the microplates system composed of Vitallium. The Vitallium plates did show significant amount of scatter with the mini, micro, and micromesh system. Removal of the scatter resulted in slight improvement in the anatomic detail.

Conclusion: Titanium plating systems do not cause any radiation scatter. The MediCad software system allows removal of the scatter found with the Vitallium plates, which helps clarify the underlying anatomy.

Improvements in the generation of thin-sliced computed axial tomographic (CAT) data by the development of new software systems have permitted the use of three-dimensional CAT scanning to aid in both diagnosis and treatment planning. CAT imaging is also used postoperatively to assess results and to evaluate recurrent disease. The advantages that rigid internal fixation offer, however, can be outweighed by the amount of scatter that some metals have on postoperative CAT scans. Several rigid fixation systems used today are composed of either commercially pure titanium or a cobalt chromium molybdenum alloy (Vitallium, Howmedica, Rutherford, NJ). The purpose of this study was to compare the amount of scatter produced by the microplates and miniplates of these two types of plating systems. The software (MediCad Inc, Cedar Knolls, NJ) used in the study has the ability to remove scatter, and the effect of this process on clarification of the underlying anatomy was also investigated.

Materials and Methods

Three adult pig heads were used in this study. The nasofrontal region was exposed through a sagittal in-
cision with two terminal lateral incisions, followed by elevation of the pericranium from the nasal and frontal bones bilaterally. On the first specimen, plates composed of titanium were used. Two miniplates were placed in the superior aspect of the nasal bone between the orbits and two miniplates were placed in the inferior portion of the nasal bone. In between the two miniplates were two microplates also made of titanium (Fig 1). The second specimen was similarly plated with four miniplates and two microplates, of similar configuration, composed of Vitallium. In specimen 1, the titanium miniplates were 1 mm thick and the screws were 2 mm in diameter and 5 mm in length. The titanium microplates were .6 mm thick and the screws were 1 mm in diameter and 5 mm in length. In specimen 2, the Vitallium miniplates were .7 mm thick, but the screws were similar in diameter and length to the titanium screws. The Vitallium microplates had a thickness of .55 mm and the screws measured .85 mm in diameter and 5 mm in length. On the third pig head, micropan fixation Vitallium mesh, 2 x 1 cm in size and .3 mm thick, was placed on the nasal bones. In all specimens, the soft tissues were closed in a similar fashion over the plates.

A CAT scan was performed on a GE 9800 scanner using 1.5-mm axial slices with 1.5-mm overlap and 512 x 512 resolution. The data from the CAT scans were reconstructed into three-dimensional scans using the MediCad 3-D software running on a Silicone Graphics 4D-25 Personal Iris (Silicone Graphics Inc, Mountain View, CA). The amount of scatter from each plate was quantitated using the MediCad software measuring tool, and the surface intensity was not manipulated during this process. The threshold, which is

FIGURE 1. Diagram showing the location of the miniplates and microplates.

FIGURE 2. The MediCad system. The two small screens to the right show scatter from the plating system (scatter is black). The paint tool removing the scatter is seen in the center and magnification screen is to the left.

FIGURE 3. CAT slice of a miniplate composed of titanium. No scatter is seen.
the number of Hounsfield units that allows radiopacity of the object being scanned, was analyzed at 30 and 75 U. The maximum amount of scatter was found at a threshold of 75 U, which is also the ideal threshold for bone. Each of the individual slices of the CAT scans were then reviewed at a threshold of 75 U, and the length of scatter for each slice was measured. The average amount of scatter for each plating system was then determined. The scatter was then removed using the MediCad paint tool from each of the individual CAT slices. The macroscreen provided on the MediCad system was used to magnify the involved area of scatter by a factor of two (Fig 2), thus allowing a more accurate removal of the scatter.

Results

Specimen 1, which contained the commercially pure titanium plating system, showed no scatter from either the microplate or the miniplate system (Fig 3). However, specimen 2, which contained the Vitalium plating system, showed a significant amount of scatter from both the microplate and the miniplate system (Figs 4, 5). In this specimen, the miniplates had an average scatter length of 16.5 mm (range, 12.0 to 26.5 mm), and the microplating system had an average scatter length of 7.5 mm (range, 7.6 to 8.1 mm). Specimen 3, which contained the Vitalium mesh, showed a small amount of scatter.

When the scatter was removed from the individual CAT scan slices from specimen 2 using the paint tool, it did improve the detail somewhat, but the anatomy was still not as clear as in the CAT scan with the titanium plating system (Figs 6, 7). There was excellent anatomic clarity of the reconstructed three-dimensional CAT scan of the skull with the commercially pure titanium system.

Discussion

The issue of scatter in obscuring the underlying anatomy has become an area of great interest, especially

![FIGURE 4. CAT slice of a miniplate composed of Vitalium. Note the scatter compared with Figure 3. The measuring tool is determining the length of scatter.](image)

![FIGURE 5. CAT slice of a microplate composed of Vitalium showing the scatter.](image)

![FIGURE 6. Three-dimensional CAT reconstruction of the pig's snout. A. Significant scatter is seen with the Vitalium plating system, as well as distortion of the underlying anatomy. B. No scatter is seen with the titanium plating system.](image)
in the field of craniomaxillofacial and neurologic surgery. Because these patients may require multiple reconstructive procedures, and possibly may require repeated CAT scans postoperatively, consideration should be given to the type of plating system that is used. This is especially true in neurosurgical patients who may require reconstruction secondary to a traumatic or an oncologic problem and will need a series of postoperative CAT scans to rule out the subsequent development of intracranial pathology. However, even a minimal amount of scatter could possibly obscure such pathology. Some surgeons believe that a Vitallium plating system offers more rigid fixation and this is viewed to be especially helpful in the maxillary region. In these cases, the appropriate software may allow improved visualization of the underlying anatomy by removing the scatter.

The results of this study have been confirmed in a recent study on cadaveric skeletons. In this study titanium produced the least scatter. Vitallium produced the most, and stainless steel produced an intermediate amount of scatter. The titanium resulted in no skeletal distortion in the three-dimensional CAT reconstruction. The scatter potential of a metal should be considered preoperatively, because these plates remain in the patient for a lifetime and not only may obscure important anatomic detail in the immediate postoperative period, but also later in life.

Acknowledgment

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References

Given similar thicknesses and mass between fixation systems, the atomic number of the constituent metals explains the differences in the amount of artifact seen. Titanium (pure) has the lowest number at 22, while Vitallium (60% cobalt-30% chromium-10% molybdenum) has an aggregate number of roughly 27.6. It is interesting that such seemingly small differences in metal densities result in dramatic changes in the amount of radiographic distortion.

The ultimate questions are, however, do these radiographic differences have any clinical significance and should they have any influence on the type of fixation system that one uses. In the overwhelming majority of clinical situations, I do not think so. It is unusual to do postoperative CT imaging of most types of surgical cases in which metal fixation has been used (eg, fractures, osteotomies). Even if it is done, a good clinical examination will usually provide the information that may be distorted on the scan. In select types of patients, such as pediatric craniofacial and head-neck/neurological oncology, however, serial CT scans are typically performed post-operatively. In these patients, minimal artifact production is of great importance and the amount, location, and type of metallic implant placement should be considered in light of this need for accurate radiographic information. It is likely in the immediate future, however, that software programs will be capable of reducing or eliminating this problem, as the authors have shown.

References