Sygnatura: Pol J Radiol, 2005; 70(4): 35-40

Polish Journal of Radiology
www.PolRadiol.com
ORIGINAL ARTICLE

Otrzymano: 2005.01.25
Zaakceptowano: 2005.07.27

MR and CT imaging of orbital alloplastic prostheses

Obrazowanie metodą MR i TK alloplastycznych materiałów protezujących oczodołów

Marek Olszycki[1], Marcin Kozakiewicz[2], Piotr Arkuszewski[2], Arkadiusz Rotkiewicz[1], Ludomir Stefańczyk[1]

[1] Medical University of Łódź, Department of Radiology, Łódź, Polska
[2] Medical University of Łódź, Department of Maxillofacial Surgery, Łódź, Polska

Praca finansowana ze środków prac własnych Uniwersytetu Medycznego w Łodzi nr 50211-326, wykonana w USK nr 1 im. N. Barlickiego, 90-153 Łódz, ul. Kopcińskiego 22

Adres autora: Marek Olszycki, Zakład Radiologii-Diagnostyki Obrazowej Uniwersytetu Medycznego w Łodzi – Samodzielny Publiczny ZOZ Uniwersytecki Szpital Kliniczny nr 1 im. N. Barlickiego 90-153 Łódź, ul. Kopcińskiego 22, e-mail: sneczku@poczta.onet.pl

Summary

Background: The aim of the study was to evaluate the CT and MRI visualization of orbital alloplastic prostheses as well as their polypropylene fabric and titanium mesh. The second focus was to investigate the usefulness of digital fusion of CT and MRI examinations.

Material/Methods: Twenty-seven patients suffering from orbital injury underwent reconstructive surgery. The globe was supported by a polypropylene fabric or titanium mesh. Afterwards, CT and MRI exams were performed to analyze the visualization of the implanted grafts and to assess artifacts caused by the alloplastic material. Finally, CT/MRI digital image fusion of all the examinations was applied.

Results: All the post-surgery CT scans showed the titanium mesh clearly, with no significant artifacts. The MR images in all those cases revealed only an area of metal-artifact, but the surrounding tissues could be satisfactorily evaluated. The fused CT/MR images depicted that implant against the background of soft tissues well. The polypropylene fabric was not well visualized by either CT or MRI examination.

Conclusions: The titanium implant could only be visualized using CT, but the intraorbital soft tissues were better depicted in MRI. Their digital fusion combined the advantages of both modalities. The polypropylene fabric was not well visualized by either CT or MR.

Key words: **MRI • CT • orbital injury • alloplastic prosthesis • digital fusion**

PDF file: http://www.polradiol.com/pub/pjr/vol_70/nr_4/6939.pdf

Background

The aim of the survey was to evaluate the computed tomography (CT) and magnetic resonance (MR) imaging of the alloplastic material – polypropylene texture and titanic mesh – implanted within the orbital wall in post traumatic patients.

We also investigated the diagnostic usefulness of CT and MRI digital image fusion of these examinations.

Materials and methods

In the years 2001–2003 the 27 patients (exclusively males, mean age 29) after orbital walls fracture underwent recon-

structive surgery: the affected globes were supported with the alloplastic material and the maxillary sinus was separated from the orbit. In the 15 patients polypropylene texture and in the next 12 ones titanic mesh was implanted (Fig. 1).

After surgery spiral CT (Picker PQ 5000) and MR (Siemens Magnetom Vision Plus 1,5T) examinations in the same coronal planes were performed in order to assess postoperative orbital morphology, to visualize implanted grafts and evaluate artifacts caused by the alloplastic material.

The exact used parameters are presented in the table 1 and the table 2.

The CT and MR raw data digital fusion of all the examinations was applied, using the own program "Dental Studio", which was designed to work in the standard PC enviroment. "Dental Studio" unifies CT and MR images into the same computer graphic format. This allows the operator to perform correction of the geometrical distortions and the grey scale/grey palette composition, which produce the fused image.

Images of the both modalities and the CT/MR fusions were analyzed separately by the two experienced radiologists (L.S., M.O.; grading: 0–1–2–3) according to the quality of visualization of the post surgery orbital morphology and the implanted grafts. We evaluated depiction of the orbital walls, muscles, optic nerve, orbital fat and the prosthesis.

Table 1. Spiral computed tomography scanning protocol of the face.
Tabela 1. Protokół badania TK twarzy.

Parameter	Value
scanning time	10–12 sec.
collimation	3,0 mm
pitch	1,5
matrix	512 x 512

Table 2. MR imaging protocol of the face (head-neck coil, slice thickness: 3 mm, matrix: 512x512).
Tabela 2. Protokół badania MR twarzy (cewka głowowo-szyjna, grubość warstwy 3 mm, matryca 512x512).

Spin echo (SE) T1-weighted	
Parameter	**Value**
Time of repetition (TR)	500–600 ms
Time of echo (TE)	14 ms
Field of View (FoV)	188 x 255 mm
Distance factor	0,1 mm
Spin echo (SE) T2-weighted	
Time of repetition (TR)	5300–5400 ms
Time of echo (TE)	30 ms
Field of View (FoV)	175 x 256 mm
Distance factor	0,1 mm

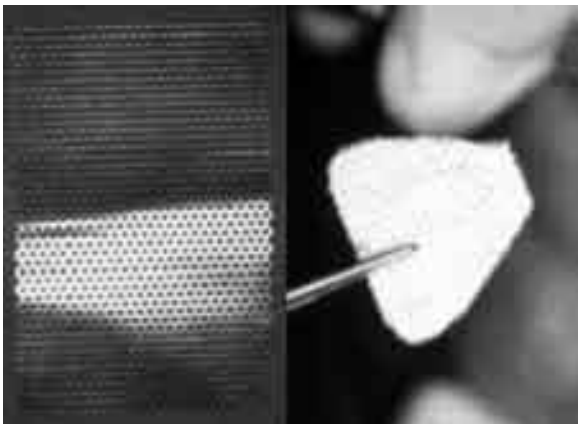

Figure 1. Titanium mesh (left) and polypropylene fabric (right).
Rycina 1. Siatka tytanowa (po lewej) i dzianina polipropylenowa (po prawej).

The second focus of evaluation was to assess image artifacts caused by the alloplastic material within the surrounding structures.

Results

The MRI depicted the orbital tissues more clearly then CT, excluding the background skeleton; bones were visualized satisfactory only in the CT. The CT scans showed titanium graft clearly, whereas the MR images revealed only small areas of metal-artifacts (Fig. 3). In the all CT/MR fused images soft tissues and titanium implants were well visible (table 3).

The polypropylene texture was not well visualized neither by CT nor MR examination (Fig. 4, 5), (table 4).

The detailed results of the survey analysis are presented in the tables 3 and 4.

All the patients had been also ophthalmologic examined (Fig. 2). During initial presurgery examination diplopia was found in 60% of cases. In all diplopic cases the hernia included inferior rectus muscle. But in further 10% of case this muscle was also involved in the hernia without ophthalmologic symptoms. In all the patients normal vision was found after surgery in the period of 2 months.

Figure 2. Test of inactive mobility of the globe. pre-surgery: block of the up-movement (left), post-surgery: full range of the movement (right).
Rycina 2. Badanie ruchomości gałki ocznej: przed operacją – brak ruchomości do góry (po lewej), po operacji – pełen zakres ruchu (po prawej).

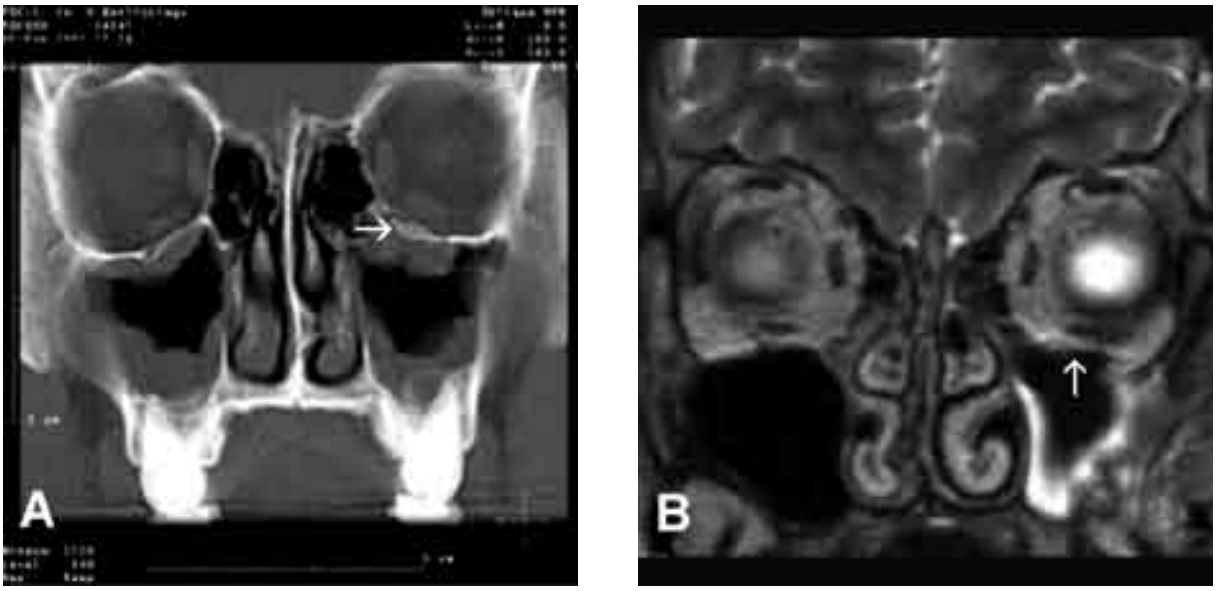

Figure 3. Patient R.A. **a**: CT MPR in the frontal plane: titanium mesh reconstructed bone defect in the orbital floor well visible (arrow), **b**: MRI T2-weighted image: titanium implant as a small area of metal-artifacts in the orbital floor (arrow).

Rycina 3. Pacjent R.A. **a**: TK MPR w płaszczyźnie czołowej: dobrze widoczna siatka tytanowa zamykająca ubytek kostny w dnie oczodołu (strzałka), **b**: MR obraz T2-zależny: tytanowy implant – niewielki obszar artefaktów w dnie oczodołu (strzałka).

Table 3. Survey of results of the group with titanium mesh (n=12).

Tabela 3. Wyniki w grupie siatki tytanowej (n=12).

Radiologist		L.S.				M.O.				Total			
Grading		0	1	2	3	0	1	2	3	0	1	2	3
CT	Orbital wall				12				12				24
	Muscles		2	10			3	9			5	19	
	Fat				12			1	11			1	23
	Optic nerve		4	8			5	7			9	15	
	Graft				12				12				24
	Artifacts	12				11	1			23	1		
MR	Orbital wall		12				12				24		
	Muscles				12			1	11			1	23
	Fat				12				12				24
	Optic nerve				12				12				24
	Graft	12				12				24			
	Artifacts		7	5			8	4			15	9	
CT/MR	Orbital wall				12				12				24
	Muscles				12				12				24
	Fat				12				12				24
	Optic nerve				12				12				24
	Graft				12				12				24
	Artifacts		7	5			8	4			15	9	

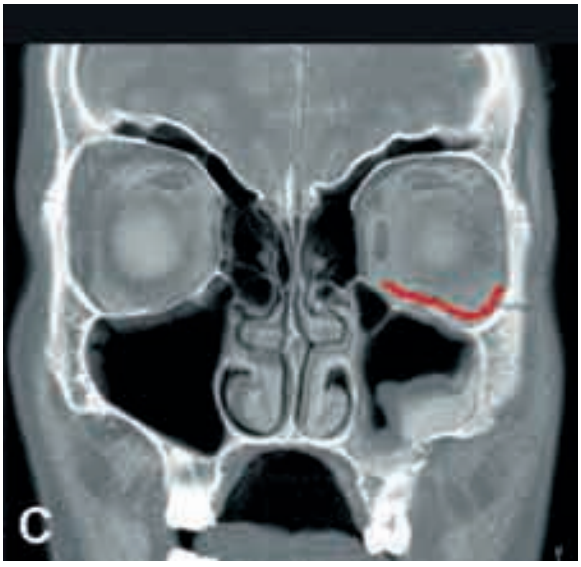

Figure 4. Patient S.R. CT (**a**) and MRI T2-weighted (**b**) in the frontal plane 2 days after surgical intervention and application of the polypropylene fabric on the orbital floor. Bone frame of the left orbit is surgically reconstructed. Alloplastic material is not visible. **c**: CT and MRI fusion. Red line indicates place of the fabric implantation on the left orbital floor.

Rycina 4. Pacjent S.R. TK (**a**) i obraz T2-zależny MR (**b**) w płaszczyźnie czołowej 2 dni po zabiegu i implantacji dzianiny polipropylenowej w dnie oczodołu. Ograniczenia kostne lewego oczodołu zostały zrekonstruowane. Alloplastyczny materiał nie jest dostrzegalny. **c**: cyfrowa fuzja TK/MR. Czerwona linia wskazuje miejsce implantacji dzianiny polipropylenowej w dnie lewego oczodołu.

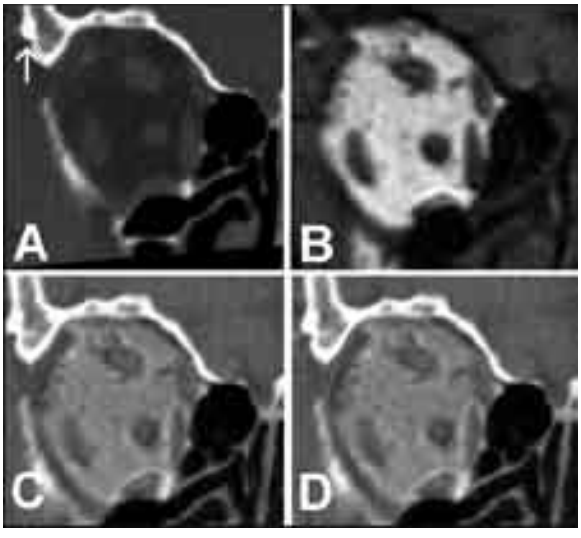

Figure 5. Patient C.S. Frontal CT (**a**) and MRI T1-weighted (**b**) scans through the orbits after bone fragment reposition and application of polypropylene fabric into the right orbit to cover the bone defect in the lateral wall. Alloplastic material is not visible. Arrow indicates place of typical titanium plates and screws used for osteosynthesis. **c**: CT/MRI fusion. **d**: Fused image: red line indicates place of the fabric implantation on the lateral wall.

Rycina 5. Pacjent C.S. Czołowe warstwy TK (**a**) i T1-zależne warstwy MR (**b**) przez oczodoły po repozycji odłamów i implantacji dzianiny polipropylenowej na bocznej ścianie prawego oczodołu. Alloplastyczny materiał nie jest dostrzegalny. Strzałka wskazuje pozycję typowych płytek i śrub tytanowych użytych do osteosyntezy. **c**: fuzja TK/MR. **d**: Obraz po złożeniu: czerwona linia wskazuje miejsce implantacji dzianiny polipropylenowej na ścianie bocznej prawego oczodołu.

Table 4. Survey of results of the group with polypropylene fabric (n=15).
Tabela 4. Wyniki w grupie dzianiny polipropylenowej (n=15).

Radiologist		L.S.				M.O.				Total			
Grading		0	1	2	3	0	1	2	3	0	1	2	3
CT	Orbital wall				15				15				30
	Muscles		3	12			5	10			8	22	
	Fat			1	14			3	12			4	26
	Optic nerve		5	10			5	10			10	20	
	Graft	15				15				30			
	Artifacts	15				15				30			
MR	Orbital wall		15				15				30		
	Muscles				15			1	14				
	Fat				15				15				30
	Optic nerve				15				15				30
	Graft	15				15				30			
	Artifacts	15				15				30			
CT/MR	Orbital wall				15				15				30
	Muscles				15				15				30
	Fat				15				15				30
	Optic nerve				15				15				30
	Graft	15				15				30			
	Artifacts	15				15				30			

Discussion

Titan and polypropylene, besides bioactive glasses, glass-ceramics, teflon, silicone and polyethylene, belong to the alloplastic materials widely used for the repair of bone defects within the orbit (1,2,3,4). CT and MRI are the principal radiological methods for monitoring this group of patients (5,2). Digital image fusion is a promising computer-based technique, which can unify data from the various imaging modalities of radiology and nuclear medicine (6,7).

In all our patients the CT scans showed titanium mesh clearly – its location, adaptation to the bone surface, separation of the orbit from sinuses, and form/shape of the implant, with no significant artifacts, which correspond to the results of other authors (3,8,9). The MR images in all those cases revealed only small area of metal-artifacts, but surrounding intraorbital soft tissues could be satisfactorily evaluated. The MR images, in all the patients, allowed depicting the soft tissues in the region of injury, especially the position of muscles, more clearly then CT images. The bone structures of the orbit were visualised satisfactory only in the CT images. In the all CT/MR fused images soft tissues and their location were well visible on the background of facial skeleton. The all fused CT and MR images well depicted titanium implant on the background of soft tissues.

The polypropylene texture was not well visualized neither by CT nor MR examination, thus those fused images did not reveal any additional details.

The own non-commercial "Dental Studio" program works in the standard PC "Windows" environment, thus does not demand any expensive graphic workstation, typical for the most CT and MR post processing applications. "Dental Studio" transforms DICOM images of the both modalities into the same graphic format, which allows performing geometrical and grey scale correction. This software can be easily apply to assess other facial structures, like sinuses, jaw or temporo-mandible joints. Usually producing the final fused image of one patient occupied about 20–25 minutes.

Concluding, the CT and MRI, especially their advanced post processing technique such as digital fusion, offer the sufficient quality to evaluate property of performed surgery employing the alloplastic material, excluding the image of the polypropylene texture.

Conclusions

Titanium implant could be only visualized using CT but the intraorbital soft tissues were better depicted in MRI, with no significant artifacts.

The polypropylene texture was not well visualized neither by CT nor MRI.

The CT/MR digital fusion unified the advantages of the both modalities.

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