The Accuracy of Plain Skull X-ray Examination as a Predictor of Recanalization Following Guglielmi Detachable Coil Embolisation in the Treatment of Cerebral Aneurysms

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Summary

We evaluated the accuracy of plain skull x-ray series as an imaging modality for the follow-up of cerebral aneurysm recanalization after Guglielmi Detachable Coil (GDC) embolisation.

We retrospectively reviewed of 100 consecutive follow-up angiograms and skull x-ray examinations in 78 patients harboring 82 aneurysms and in whom 85 procedures were performed. Angiography was performed between 1 and 54 months (mean: 10.8 months) after embolisation. The skull series (AP, lateral and Towne's projections) were taken at the time of follow-up angiography. Each follow-up angiogram and skull series were compared to the immediate post-coiling, correlating presence or absence of coil compaction on the skull series and recanalization of the aneurysm at angiography.

In 97 (97%) examinations, skull x-ray findings correlated with the angiographic findings. In three cases, skull x-ray examination suggested compaction when no recanalization was seen angiographically; in these three cases, the

aneurysms were small and found to be more thrombosed than baseline. In no case did angiographic recanalization occur in the absence of compaction on skull series. These findings yield 100% sensitivity, 95% specificity, 93% positive predictive value, 100% negative predictive value and 97% accuracy. The location, size, configuration and neck/dome ratio of the aneurysm were not related to the correlation between angiography and skull x-ray exam.

Skull x-ray series is a safe, accurate, and cost-effective mode of follow-up for patients with GDC-treated aneurysms. The possibility of it replacing angiography still requires a more comparative skull x-ray modality in follow-up studies.

Introduction

In many countries and institutions, embolisation with the Guglielmi detachable coil (GDC) system (Target Therapeutics/Boston Scientific, Fremont, CA)¹ is now proposed as the initial method of treatment^{2,3}.

The results of the study of Brislstra et Al⁴ in-

dicating that embolisation with coils is a reasonably safe procedure with a low complication rate not only in patients with an unruptured aneurysm but also in patients with a ruptured aneurysm in all locations⁴, with a reported re-bleeding rate of 1-4% in aneurysms treated with GDCs⁵⁻⁷.

However, the long-term outcome of intracranial aneurysms treated with GDCs is not known. Therefore, all patients with aneurysms treated with this technique must be followed with an imaging modality to depict residual intra-aneurysmal flow, or to detect repermeation of the aneurysm, and to assess the long-term stability of aneurysmal exclusion. By means of its excellent spatial resolution, digital subtraction angiography (DSA) is certainly the procedure of choice for this indication. However, DSA is an expensive and invasive method.

On the other hand, the plain skull x-ray is a relatively simple and inexpensive diagnostic method that carries no risk to patients. The changes of coil configuration can be detected in plain skull x-ray by comparing it with previous films. The purpose of this study is to evaluate the accuracy of plain skull series as an imaging modality for detection of cerebral aneurysm recanalization after GDC embolisation.

Methods

Patient Population

Between January 1993 and July 1999, 248 aneurysms in 236 consecutive patients were treated by endovascular packing with GDCs (Target Therapeutics/Boston Scientific, Fremont, CA) by the Sr. author (AB). Of this population we retrospectively analysed 100 follow-up angiograms and skull X-rays following 85 procedures of 82 aneurysms in 78 patients.

There were 60 females and 18 males with pa-

tient ages ranging from 13 to 78 years old (mean 53.3 years old). The 78 patients harbored a total of 82 aneurysms. 74 patients had one aneurysm each. Four patients had two aneurysms both treated. 80 aneurysms were treated once, one twice and one aneurysm was coiled three times. Seventy-two procedures had one follow-up angiography and skull X-ray. Two follow-up studies were available in 11 procedures and three follow-up in two procedures.

Forty-two (51%) aneurysms were located in the anterior circulation and 40 (49%) arose from the posterior circulation.

For packing the aneurysmal lumen, both GDC-18 and GDC-10 coils were used.

Data Analysis

Two neuroradiologists independently and blindly reviewed DSA and skull x-ray. Consensus was always obtained in cases of discrepancy between both readers.

Results

In 97 (97%) examinations, skull x-ray findings correlated with the angiographic findings (table 1) (figures 1, 2). In three cases, skull x-ray examination suggested compaction but no recanalization was present angiographically; in these three cases, the aneurysms were small and found to be actually more thrombosed than baseline (figures 3, 4). In no case did angiographic recanalization occur in the absence of compaction on the skull series.

These findings yield 100% sensitivity, 95% specificity, 93% positive predictive value, 100% negative predictive value and 97% accuracy. The location, configuration and neck/dome ratio of the aneurysm were not related to the correlation between angiography and skull x-ray examination.

Table 1 The results of the correlation between skull x-ray examination and angiography

		Skull X-ray		Total
		Compaction +	Compaction -	
Angiogram	Recanalization +	37	0	37
	Recanalization -	3	60	63
Total		40	60	100

Figure 1 A 43-year-old female underwent endovascular coiling due to ruptured basilar tip aneurysm (Grade III) (A). The aneurysm was successfully coiled with 90% occlusion (B). Skull x-ray (C) and angiography (D) performed 14 months after coiling showed no compaction and total occlusion of the aneurysm.

Discussion

The goal of the endovascular treatment of intracranial aneurysms with the GDC system is to exclude the aneurysm from the circulation by filling it with platinum microcoils. Achieving a complete aneurysm occlusion at the first session and closely following and retreating patients with subtotally occluded aneurysms are important factors in attaining consistent and excellent clinical results⁸. Preliminary study suggests a durable result when the aneurysm is completely packed with coils⁹.

Although subtotal endovascular GDC treatment has the potential to favorably alter the

natural history of ruptured intracranial aneurysms by a combination of intra-aneurysmal thrombosis^{10,11}, and flow modification¹², definitive protection from aneurysmal regrowth and rupture is provided only by stable, and total obliteration.

Endovascular GDC procedures leave a defect in the aneurysm/parent vessel interface and rely instead on intra-aneurysmal thrombosis to fill the spaces between the coils and the aneurysm cavity^{10,11,13,14}, whereas surgical clipping attempts to approximate and seal off the arterial wall defect. Therefore, unless endothelialization of the aneurysmal orifice occurs, the coil-treated aneurysm is susceptible to reper-

Figure 2 A 54-year-old female underwent endovascular coiling for an incidentally found unruptured right cavernous carotid aneurysm (A) with an occlusion grade of less than 90% (B). Seven months after coiling, the aneurysm shows compaction on skull x-ray (C) and recanalization in the inferior portion of the aneurysm on angiography (D).

meation by either thrombolysis or haemodynamic stress¹⁵.

Since the long-term outcome of intracranial aneurysms treated with GDCs has not been well established at present time, the issue of GDC instability and angiographic repermeation of aneurysm necks is of considerable clinical importance, mainly in young patients, or those that can be treated with both coils or clipping. Mericle et al indicated that initially totally occluded aneurysms could undergo significant repermeation as late as 24 months after embolisation¹⁶.

In some patients the aneurysm may recur, either because of coil compaction or because of regrowth of a residual aneurysmal neck. Moreover, some aneurysms cannot be completely packed with coils, and residual filling within the interstices of the coil mass or a residual aneurysmal neck is left after treatment. Recent

reports of midterm clinical results for the GDC method revealed post-GDC treatment haemorrhage rates that increased from 0% for small aneurysms to 4% for large aneurysms and ultimately to 33% for giant lesions⁸. Therefore, all patients with aneurysms treated with GDC should be followed to assess the durability of the initial treatment and the long-term stability of aneurysmal exclusion, or to diagnose the occurrence of remnant regrowth, and to determine the need for further therapy to prevent the consequence of future haemorrhage. If residual aneurysm or aneurysmal regrowth is identified, retreatment is considered.

Patients treated with GDCs are routinely studied after therapy with conventional digital subtraction angiography (DSA). DSA is considered the "gold standard" investigation for follow-up. If performed and interpreted by an experienced endovascular surgeon, it has a sen-

Figure 3 A 48-year-old male, 5 years s/p surgical clipping for a ruptured anterior communicating aneurysm, presented with SAH, 2 days prior to coiling. The angiography (A) showed small anterior communicating artery aneurysm and endovascular coiling was performed with less than 90% occlusion (B). Comparison of skull x-rays obtained immediately postembolization (C) and 12 months later (D) revealed a change in coil configuration, but the angiography (E) showed a more thrombosed aneurysm without recanalization.

sitivity approaching 100%. Angiography which clearly provides superior resolution of vascular anatomy surrounding a treated aneurysm is the most accurate means of following of patients treated with GDCs for intracranial aneurysms

and of assessing the need for further treatment. Furthermore, additional therapy can be pursued at that time, if necessary.

However, DSA is expensive, invasive and carries some risk to the patient^{17,18}. Mani and

Figure 4 An incidentally found small left superior hypophyseal aneurysm (A) in a 63-year-old female was coiled utilizing 2 GDCs, resulting in 95% occlusion (B). Ten months s/p coiling, the skull x-ray (D) showed flattening of the anterior portion of the coils as compared with immediate postembolization skull film (C). No recanalization was found on angiography (E).

Eisenberg¹⁹ have shown that the complication rate depends to a certain degree on the duration of an angiographic study. The time necessary for an angiographic study using DSA has decreased significantly, and the use of non-ionic iso-osmotic contrast media has reduced the hazards of neurotoxic side-effects^{20,21}. In our own experience the risk of diagnostic angiography is very small (1/1200), but it is not risk-free.

Noninvasive imaging techniques, such as MR angiography, transcranial color Doppler sonography (TCCD), and three-dimensional CT to visualize cerebral vessels have shown rapid progress over the past decade in both quality and availability. Unlike DSA, MRA provides intracranial vascular study without an invasive procedure and without risk. Although GDCs do not produce artifacts and cause very little signal loss of the surrounding tissue^{22,23} the special resolution is not good enough to exclude a small recanalization.

According to the study of Derdeyn et Al²², MR angiography can identify a residual aneurysmal neck and the presence of flow in parent and branch vessels after treatment with GDCs. It can identify flow within a treated aneurysm, but with less accuracy. In addition, haemorrhage and artifacts, a thin rim of high signal which was often encountered in the frequency-encoded direction that may mimic residual flow within the aneurysm. They also reported a lower sensitivity (71%) for identification of residual flow within the coil mass, but a higher sensitivity (100%) for identification of residual flow within the neck and highlighted that the arterial signal could be obscured in the vicinity of the coil mass²². In terms of cost effectiveness, MRA is still expensive and takes about an hour to finish the study.

TCCD may also be considered reliable as a noninvasive technique for long-term follow-up of the patients after GDC treatment²⁴. However, color Doppler twinkling artifact related to microcoil architecture might represent a potential pitfall in the evaluation of aneurysmal cavity thrombosis²⁵.

The metallic artifacts of the coils prevent the use of CTA. On the other hand, the plain skull x-ray is a simple and cheap diagnostic method that carries no risk to patients.

Havukainen and Pirinen²⁶ evaluated patient dose and image quality in five standard X ray examinations, which showed that the means and

range of variation for the entrance skin air Kerma values for skull lateral X-ray was 3.1 mGy (1.1 - 7.7 mGy). Changes in coil configuration can be detected in plain skull x-ray by comparing them with previous films. To our knowledge, no studies reported concerned this project.

In our Institute, the standard follow-up on patients treated with GDC is; skull x-ray in three weeks, three months, and six months each, skull x-ray and angiography in one year, skull x-ray in two years, and skull x-ray and angiography at five years.

Both imaging modalities were always performed at the same time. Therefore, the probability that an event occurred between DSA and skull x-ray and modified the appearance of aneurysm or coil mass was low.

In this study, no case presented angiographic recanalization in the absence of compaction on skull series, which yield 100% sensitivity. This suggests that a skull x-ray is an excellent screening method of follow-up study following endovascular coiling of the aneurysm. As we can see on the result, there were three cases, which showed compaction when no recanalization was present angiographically. All of these three aneurysms were small (3 x 5 x 3 mm, 6 x 7 x 6 mm, and 3 x 3 x 6 mm). This might be due to subtle differences in the projection angle of skull x-ray. In our institute, skull AP, lateral, Towne's and water's view is routinely taken for the skull x-ray follow-up. In the future, to remove this false positive result we are using three-dimensional reconstructed skull x-ray, obtained in our rotational- 3D angiographic system (Siemens Neurostar TOPS Siemens Medical Systems Forchheim, Germany), which provides an infinite variety of different views.

Conclusions

Skull x-ray demonstrates the change in coil mass itself not the intra-aneurysmal haemodynamic status. At this point skull x-ray cannot completely replace DSA for follow-up of GDC-treated aneurysms. However if there is a change in coil shape, angiography is indicated to evaluate the aneurysm. DSA is still considered the "gold standard" investigation to identify the recanalization of aneurysm treated with coils even though it is being replaced by less invasive technique such as CTA, MRA and simple skull x-ray as shown in our study. These

modalities can prevent repeated angiographic follow-ups in simple wall neck lesions. With the new three-dimensional capabilities, plain x-ray examinations may provide highly accurate and reproducible results.

Our review indicates that follow-up with skull x-ray is worth considering for the patients treated with coils in terms of its simplicity. In the older population, where angiography car-

ries the highest risk, we feel comfortable with the Skull series as the sole follow-up imaging technique. Skull x-ray is much easier, costs much less and is a safe mode of follow-up for patients with GDC-treated aneurysms. The possibility of it replacing angiography in the majority of patients still requires a more comparative skull x-ray modality and longer follow-up studies.

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