The Value of CT Angio Brain for Follow up of Clipped Cerebral Aneurysms; The Impact of Aneurysm Clip Material

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Citation

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Abstract

The aim of this study was to evaluate the impact of different aneurysm clip materials on the accuracy and image quality of post-operative CT angiography (CTA) emphasizing the completion of aneurysm obliteration. From January 2012 to, Jan 2016; forty-five patients harboring fifty-four cerebral aneurysms with 44 ruptured and 10 unruptured cerebral aneurysms have been treated with open surgical clipping and underwent post-operatively follow up CTA. The results were analyzed regarding the diagnostic yield in view of metallic artifacts with different clip material and at different aneurysm locations. Out of the forty-five cases; 28 patients (62.2%) were treated by titanium aneurysm clips only, three patients (6.7%) with Codman clips only, and nine patients (20 %) with Elgiloy clips (Sugita) only while in five patients (11.1%) different types of clips (mixed) were used. The CTA was informative regarding the target of the study in 37 patients (82.2%) while in eight patients (17.8 %) was none informative either with dense metallic artifacts and/or near the skull base location and so hindering the CTA accuracy in FU of clipped cerebral aneurysms. The Elgiloy and Codman made clips, skull base locations showed less diagnostic yield and even can miss residual aneurysm filling that can be detected only with DSA. Titanium made aneurysm clips showed less metallic artifacts and can increase the diagnostic yield and accuracy of CTA follow up after aneurysm clipping specially when being away from skull base locations.

INTRODUCTION:

Patients with a history of spontaneous subarachnoid hemorrhage (SAH) will be at risk for development of new aneurysms in spite of successful management of the ruptured cerebral aneurysm at time of their initial bleed.1) In reported studies, the incidence of de novo cerebral aneurysms occurrence was reported as 0.8 - 2.2% per year, on the other hand the incidence of aneurysm re-growth after clipping was 0.5% per year. 2-4)

The presence of multiple cerebral aneurysms was reported to range from 14% to 45%, with most authors indicating a range between 20-30%.5) Thus, after surgically treated cerebral aneurysms, follow-up imaging of the remaining part of Willis' circle is recommended. 5,6,7)

Although imaging after cerebral aneurysm clipping traditionally has been achieved using digital subtraction angiography (DSA), magnetic resonance angiography (MRA) might be an alternative only when the aneurysm clip is MR-compatible. The susceptibility artifact from the metal clip would compromise image quality. The artifact is being worse in the immediate vicinity to the clip, and it cannot easily be directed away from the remainder of the circle of Willis. 6-9)

CT angiography (CTA) may provide an acceptable alternative in many cases, particularly for long-term postoperative follow-up. 5,6,7) CT angiography as a non-invasive procedure could be an acceptable and effective technique for the assessment of cerebral aneurysms. The thin collimation used in CT angiography tends to reduce degradation of image from cerebral aneurysm clips. There are also some other artifacts reducing ways: higher kVp (140), mild head tilt, perpendicular clip position to the scan plane, as well as titanium clips rather than cobalt alloy clips. 6-9) The aim of this study is to evaluate the impact of different aneurysm clip materials on the accuracy and image quality of post-operative CTA emphasizing the completion of aneurysm obliteration.

MATERIALS & METHODS:

From January 2012 to January 2016, forty-five patients harboring fifty-four cerebral aneurysms with 44 ruptured and 10 unruptured cerebral aneurysms have been treated with open surgical clipping. The study was conducted at the Mansoura University hospital; neurosurgery & radiology departments, as well as the Prince Mohamed bin AbdelAziz Hospital, Riyadh, Saudi Arabia. All except one patient were referred from the ER (44 patients 97.8 %) and presented with severe headache and/or disturbed conscious level. They underwent computed tomography (CT) of the brain that showed SAH (ruptured aneurysms). The unruptured aneurysms that have been treated in this study were either a part of multiple cerebral aneurysms, both ruptured and unruptured, and the only patient who was treated as unruptured aneurysm (2.2 %) presented with acute right 3rd nerve palsy.

Cases with unruptured aneurysms associated with additional rupture were treated in the same session if they were accessible in the same approach (i.e, AcomA + MCA, AcomA and PcomA, small ipsilateral unruptured M1 associated with large ruptured MC bifurcation aneurysm). The case who presented as an unruptured aneurysm with acute third nerve palsy was treated with clipping.

Preoperative CT angiogram of the patient group was found to harbor fifty-four cerebral aneurysms with 44 ruptured and 10 unruptured cerebral aneurysms. 51 of the diagnosed cerebral aneurysms were treated with open surgical clipping. Regarding the remaining 3 untreated cerebral aneurysms, two of them were small less than 3 mm unruptured mirror image MCA aneurysm on the contralateral side of a ruptured MCA aneurysm, and the last one was a distal PCA unruptured small aneurysm less than 3 mm in diameter as well. All patients included in the study underwent follow up CTA post-operatively before hospital discharge. The comparative results were analyzed regarding the diagnostic yield, metallic artifacts with different clip material and at different aneurysm locations.

Skull base locations for cerebral aneurysms were defined as those PcomA aneurysms, ophthalmic segment aneurysm, and dorsal wall ICA aneurysms, otherwise aneurysms were defined as non-skull base location aneurysms.

CTA was done using Philips 16 and GE 16 machine with helical acquisition, starting from C1-2 till 2 cm below the skull vault, with slice thickness: 0.6 mm,KV:120-140,mA: 750,scanning FOV:25 cm, contrast material: 50 cc with 4ml/sec rate.

IMAGE INTERPRETATION:

Images were analyzed regarding: aneurysm remnants (size, shape, wall irregularity and neck), clip location and artifacts, parent vessel state, aneurysms multiplicity, rest of Willis circle vasculature and whole brain state.

STATISTICAL ANALYSIS:

The data were computerized and statistically analyzed using SPSS (Statistical package for social sciences) version 24. Quantitative data were represented as range, arithmetic means and standard deviations (X±SD), while Qualitative data were represented as frequencies and percents. Chi-square test (χ^2) and McNemar test was carried out for calculating significant differences between the qualitative data whenever possible; otherwise “Fisher’s exact test” was used when expected cell is less than five .The result was considered statistically significant when the significant probability was less than 5% ($P < 0.05$).

The criteria of involved patients and their aneurysms were summarized in table 1

RESULTS:

Demographic data:

This study included forty-five patients 23 (51.1 %) males and 22 (48.9%) females, their age ranged between 24 and 73 years old with a mean age of 51.51 ± 12.46 years. 37 patients (82.2%) were diagnosed with single intracranial aneurysm, while eight patients (17.8%) were harboring more than one aneurysm (7 patients with 2 aneurysms, one patient with 3 aneurysms).

Cerebral aneurysm location:

Aneurysm sites were mostly located in the anterior circulation 52 aneurysm and only 2 in the posterior circulation and distributed mainly among both AcomA 21Ans, and 21 Ans in MCA (Table 1). Aneurysm sizes were mainly small (50 aneurysms) and 4 large ones and no giant aneurysms were included in this study.

Skull base location aneurysms were 7 (12.9 %) while non-skull base location aneurysms were found to be 47 (87.1%).

Aneurysm clip types:

In this study we used 3 types of different clip materials; the majority were titanium Yasargil design clips 40 in 31 patients, 7 Codman clips in 4 patients,19 Elgiloy clips in 15 patients, Mixed type aneurysm clips were used in 5 patients (table 2).

Number of applied aneurysm clips:

In this study, 66 different types and shapes of aneurysm clips were used. Only one aneurysm clip was used to achieve adequate neck closure in 27 patients (60%), while two aneurysm clips were used for the same purpose in 15 patients (33.3%) and only three clips were used in 3 patients (6.7%). Out of 54 detected aneurysms in 45 cases only 51 of them were clipped among them; 38 (74.5%) aneurysms needed only one clips, 11 (21.5%) aneurysms needed two clips and only 2 (3.9%) aneurysms needed 3 clips. For the three aneurysms that were not treated, one was distal P4 small unruptured aneurysm, and two were small <3 mm mirror image unruptured MCA aneurysms that were left for follow up.

The Diagnostic yield of post operative CT angiography:

CT angiogram was done for all patients before hospital discharge to confirm appropriate clip position, good filling of the surrounding vessels, and the presence of neck remnant if any. Out of the forty-five patients 33 patients' CT Angiograms (73.3%) were informative regarding the pre-defined target of post-operative CTA while one or more of the predefined targets were missed in 12 patients' CT Angiograms (26.7%). These finding were different significantly among patients with different aneurysm clips.

Out of our 45 patients included in the study, titanium clips alone were used in 27 cases, post-operative CT angiograms were informative in 26 of them (96.2%) while there were only four informative CT angiograms (40%) out of the 10 patients in whom Elgiloy were used alone. In patients where we used Codman clips only one out of three patients (33.3%) was informative. When different types of aneurysm clips used in the same case the diagnostic yield of CT angiograms were informative in two out of five (40%). (Table 3)

Impact of number of applied clips on the image quality of post operative CTA:

For patients in whom only one clip was sufficient to perform appropriate neck clipping, the post-operative CT angiograms were being informative in 23 out of 27 (85.2%) irrespective to the clip material, while in patients whom needed more than one clip, CT angiogram was informative to a lesser extent so that only 10 out of 15 patients (66.7%) with 2 clips applied, while none of the three patients whom needed three clips the CT Angiogram was informative. (Table 4)

Impact of clipped aneurysm site on the image quality of post-operative CTA:

Out of 38 cases with non-skull base location of clipped cerebral aneurysm 34 (77.3%) of the post-operative CTAs were informative (table 5), while in skull base located clipped aneurysms 4 /7 (57.1%) only post-operative CTAs were informative (P = .2).

Figure 1

44 years old morbidly obese female, known case of hypertension presented by acute severe headache; A: Non contrast CT brain axial cut showed diffuse SAH with intra-ventricular extension into the third ventricle, B: CT angio brain volume rendering transparent formats processed image showed wide neck AcomA aneurysm with dominant left A1, C, D, E, F: Intraoperative photos showing the AcomA aneurysm before and after successful clip application, G: postoperative non contrast CT brain axial cut showed the surgical corridor from right pterional approach and aneurysm clip in position, H, I, J: postoperative CT angio brain showing successful exclusion of the AcomA aneurysm and clearly reconstructed bifurcation; H: Sagittal reformat, I: 3D volume rendering processed image with titanium aneurysm clip in place, J: volume rendering processed image without clip, K, L: postoperative Angiogram, 3D and 2D images confirming stable occlusion of the AcomA aneurysm 2 years after the surgery.

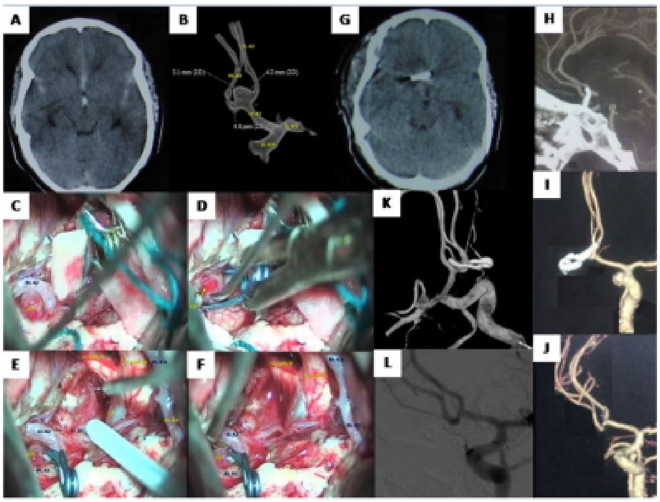

Figure 2

28 years old male, presented by acute severe headache; A: Non contrast CT brain axial cut showed diffuse SAH, B, C, D: CT angio brain axial, sagittal & volume rendering format processed images showed wide neck small pyramidal AcomA aneurysm with dominant left A1, E, F: Intraoperative photos showing the AcomA aneurysm before and after successful clip application at the aneurysm neck, G, H: postoperative CT angio brain showing successful exclusion of the AcomA aneurysm and clearly reconstructed bifurcation; G: Axial, H: coronal reformat processed image with Codman aneurysm clip in place, J, K, L: postoperative Angiogram, 2D left ICA Lat & A-P and 3D right ICA angiogram images confirming stable occlusion of the AcomA aneurysm six months after the surgery.

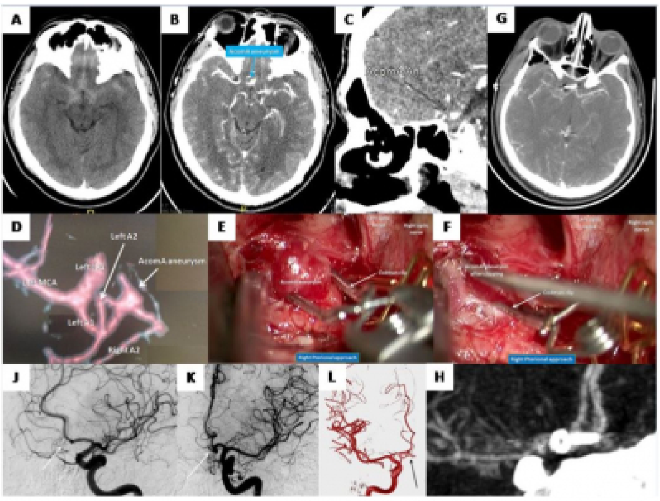

Figure 3

38 years old male, presented by acute severe headache; A: Non contrast CT brain axial cut showed focal right sylvian SAH, B, C: CT angio brain axial, 3D format processed images showed two right middle cerebral artery aneurysms; one is ruptured large wide neck oblong bifurcation aneurysm and the other is right M1 small unruptured aneurysm at the origin of anterior temporal artery, D ,E: Intraoperative photos showing both aneurysms after successful clip application on both aneurysm neck, G: postoperative non contrast CT brain axial cut showed aneurysm clip in position with significant metal artifact, H, I: postoperative CT angio brain showing significant metal artifacts with Codman aneurysm clip in place at the site of both aneurysms with fairly apparent non filling of the predescribed MCA aneurysms, I, J, K: postoperative Angiogram, 2D right ICA A-P, Lat & working angle images confirming stable occlusion of both MCA aneurysms six months after the surgery.

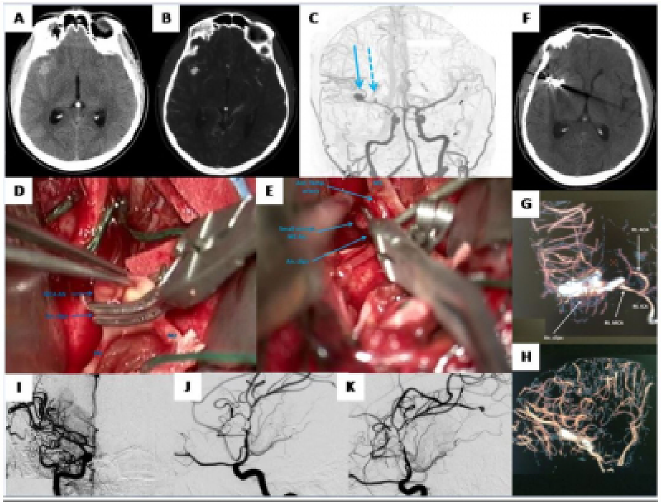

Figure 4

70 years female, known case of hypertension presented by acute severe headache followed by disturbed conscious level; A: Non contrast CT brain axial cut showed acute right fronto-tempro-parietal SDH with right sylvian and basal cistern SAH underwent emergency craniotomy evacuation of her SDH, B: postoperative non contrast CT brain axial cut showed evacuation of the SDH. C, D:CT angio brain volume rendering and transparent formats processed images showed small wide neck right PcomA aneurysm projecting laterally, E: Intraoperative photo showing successful clip application on the neck of PcomA aneurysm, F, G: postoperative CT angio brain showing significant metal artifacts with Sugita (Elgiloy) aneurysm clip in place at the site of PcomA aneurysm with fairly apparent non filling of the predescribed aneurysm, unfortunately the patient did not show up for post-operative follow up DSA.

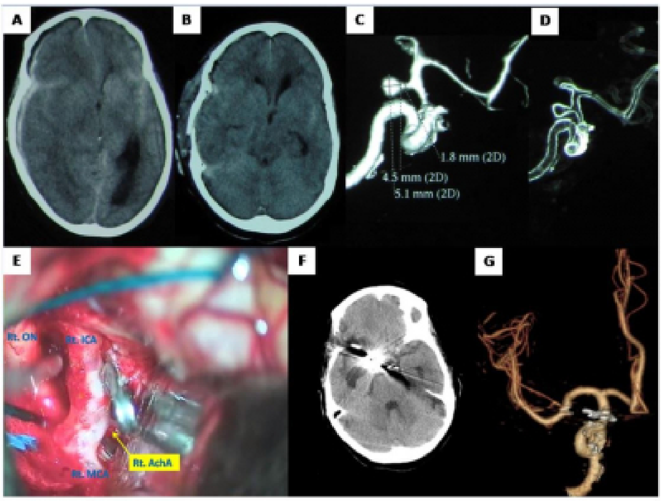

Figure 5

63 years old female, known case of hypertension presented by acute severe headache, right hemiparesis, A: Non contrast CT brain axial cut showed diffuse SAH mainly concentrated in the left sylvian fissure, B, C, D, E: CT angio brain coronal, sagittal unsubtracted images and volume rendering formats processed image showed wide neck left ICA paraclinoid aneurysm with small teat at the top indicating site of recent bleed, F: postoperative non contrast CT brain axial cut showed the surgical corridor from left pterional approach and aneurysm clips in position with significant clip artifact, G, H: Intraoperative photos showing the aneurysm before and after successful clip application, asterisk over a proximal control temporary clip on left ICA, dashed line over the neck of the aneurysm, I, J: postoperative CT angio brain volume rendering and transparent reformats showing notable metallic artifacts of the aneurysm clips (one titanium and one Sugita Elgiloy) that did not allow accurate post operative study regarding any residual neck, K,L,M,N: postoperative left ICA angiogram, lateral subtracted and unsubtracted images, A-P and 3D confirming successful exclusion of the left ICA paraclinoid aneurysm two years after the surgery.

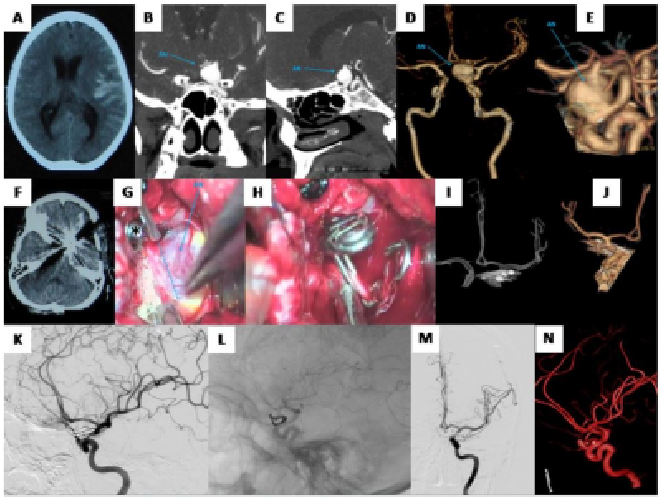

Table 1

Summary of patient criteria.

Age	24-73 Y (51.51 ± 12.46)	
Gender	22 females, 23 males	
Location	52 Ans. in anterior circulation 2 Ans. in posterior circulation	21 AcomA, 21 MCA, 5 PcomA, 4 ICA, 2 PCA, 1 DACA
Rupture state	44 ruptured 10 unruptured	
Size	Small <10 mm Large 10-25 mm	50 Ans. 4 Ans
Number of clips used	3 clips ---- 3 2 clips ---- 16 1 clip ----- 26	
Glasgow outcome score (GOS) at 6 months	5----38 4----5 3----1 2----0 1----1	
Number of aneurysms/case	3 Ans -----1	2 clipped and one for FU
	2 Ans------7	5 of 7 unruptured Ans. Clipped and 2 for FU (contralateral MCA, distal P3B small An.)
	1An -------37	

(An: Aneurysm, Ans: Aneurysms, Anterior communicating artery aneurysm: AcomA, Posterior communicating artery aneurysm: PcomA, Middle cerebral artery aneurysm: MCA, Internal carotid artery aneurysm: ICA, posterior cerebral artery aneurysm: PCA, Distal anterior cerebral artery aneurysm: DACA)

Table 2

Types of used aneurysm clips

Type of clips	Number of clips	Number of patients treated
Titanium	40	31
Codman	7	4
Elgiloy	19	15
Total number	66	50 (5 were mixed types)

Table 3

Impact of aneurysm clip material on the diagnostic yield of post-operative CTA

Types of aneurysm clips	Number of patients	Diagnostic yield of post operative CT Angiography		*P*- value
		informative	Non-informative	
Titanium	27	26 (96.2%)	1 (3.8%)	.03
Codman	10	4 (40%)	6 (60%)	
Elgiloy	3	1 (33.3%)	2 (66.7%)	
Mixed	5	2 (40%)	3 (60 %)	
Total	45	33 (73.3%)	12 (26.7%)	

Significant difference in the diagnostic yield between different aneurysm clip types used ***P= .03***

Table 4

Impact of number of applied aneurysm clips on the diagnostic yield of post operative CTA.

Number of applied aneurysm clips per case	Diagnostic yield of post-operative CT Angiography		Total number of clips	*P*- value
	informative	Non informative		
One clip	23 (85.2%)	4 (14.8%)	27	.005
Two clips	10 (66.7%)	5 (33.3%)	15	
Three clips	0	3 (100%)	3	
Total number	33 (73.3%)	12 (26.7%)	45	

Highly significant difference in the diagnostic yield between number of applied aneurysm clips ***P= .005***

Table 5

Impact of aneurysm locations on the diagnostic yield of post operative CTA.

Location of Clipped aneurysm	Diagnostic yield of post operative CT Angiography		Total number of clipped aneurysms	*P*- value
	informative	Non informative		
Skull base	4 (57.1%)	3 (42.9%)	7	.2
Non skull base	34 (77.3%)	10 (22.7%)	44	
Total number	38 (74.5%)	13 (25.5%)	51	

No significant difference in the diagnostic yield regarding different aneurysm locations ***P= .2***

DISCUSSION

Cerebral aneurysms are relatively common, representing prevalence 2.3 % in general population. 10) The diagnosis of intracranial aneurysms is being crucial to prevent the potentially dismal outcome of their rupture. 10, 11, 12)

De novo cerebral aneurysm occurrence after successful treatment was reported between 0.8 and 2.2% per year, on the other hand the incidence of aneurysm re-growth after clipping was 0.5% per year 2-4) and so post-operative radiological evaluation and follow-up of clipped cerebral aneurysm is mandatory to elucidate any residual and to monitor aneurysmal re-growth. 6, 7, 8, 9, 13)

For long time DSA was the gold standard for diagnosis and post-operative follow up of cerebral aneurysms but over the past decade CT angiogram has been used with success as a diagnostic, non-invasive tool for preoperative diagnosis, planning. 14)

The diagnostic limitation of post-operative MRI and CT angiography is due to the presence of metal clips has established the DSA golden role in follow-up of clipped cerebral aneurysms. 6)

In spite of DSA being an invasive procedure with reported complication rate ranging between 0.4%-12.2%, 11,12,15) there is still superiority of DSA in detection of neck remnant and body filling of clipped as well as coiled cerebral aneurysms. on the other hand, the compliance of patients for follow up after insertion of intracranial device is poor with reported rate at three-year post treatment, 90% the patients choose not to follow-up with radiological imaging when DSA was offered as postoperative follow up procedure. 14,15)

However, the introduction of the multi-slice CT machines with helical acquisition has modified this pre-existing dictum and 3D CT angiography using multi-detector CT machines has the potential to replace digital subtraction angiography (DSA) in order to confirm completion of aneurysm clipping rather than coiling. 10,16)

CTA is noninvasive, fast, easy procedure with lower complication rates and significantly high diagnostic accuracy especially with the new generations of CT multi-detector machines and so CTA appears to possess a promising role in the post-operative evaluation of clipped cerebral aneurysms. 2,11)

In this study we evaluated the impact of different clip materials on the quality of CTA images in patients with clipped cerebral aneurysms. CT angiogram was done for all patients before hospital discharge to confirm appropriate clip position, good filling of surrounding vessels, and the presence of neck remnant if any. Out of forty-five patients in this study 33 patients' CT angiograms (73.3%) were informative regarding the pre-defined target of post-operative CTA while one or more of the predefined targets were missed in 12 patients' CT angiograms (26.7%). These finding were different significantly among patients with different aneurysm clips.

The results of the current study were comparable to those of Teksam and his colleagues 17) who compared the diagnostic accuracy of CTA to DSA in 9 aneurysms, where he could diagnose one residual neck and two recurrences using CTA that had been confirmed by DSA while in five out of nine aneurysms no residual or recurrence could be detected by either CTA or DSA. However, two recurrences were detected by DSA and could not be detected by CTA as it was less than 2 mm in diameter and there were no false positive recurrences detected by CTA. 17)

The metal artifact of the clips is considered the main challenge in the image quality and aneurysm residual/recurrence evaluation and frequently hampers the evaluations of the surrounding vasculature. 6,7,13,18) Metal aneurysms clips produce beam hardening artifacts that limits the diagnostic accuracy of cerebral CT angiography.

Although these artifacts are not so severe when compared to those occurring with MR angiography, the quality of CT images is limited in the areas adjacent to surgical clips. The titanium clip produces less artifact than the cobalt containing alloy aneurysm clip.19, 20, 21)

In this study, three different types of clip material were used; the majority was titanium Yasargil design clips 40 in 31 patients (Figure 1), 7 Codman clips in 4 patients (Figure 2,3), 19 Elgiloy clips in 15 patients (Figure 4); mixed type aneurysm clips were used in 5 patients (Table 3).

Phantom and clinical investigations showed that artifacts produced by titanium clips on both CT and MR are minor when being compared to the cobalt alloy aneurysm clips. Also, combining titanium clips with Spiral CT angiography (CTA) could be an acceptable mode of post-operative angiographic control and could be applied to determine completeness of aneurysm elimination, adjacent vasculature patency as well as vasospasm.7,20) The currently available cobalt based cerebral aneurysm clips are Phenox and Elgiloy. It is not rare to see image artifacts in computed tomography (CT) and magnetic resonance (MR) imaging leading to failure in delineating the anatomical structures around the clips. 20) Our results matched the authors about the significant artifacts produced by the cobalt clip as well as stainless steel alloy Codman clips which mask the vicinity of the clip in some cases.

In this study, out of the 45 patients included in this study, titanium clips alone were used in 27 cases and their follow up CT angiograms were informative in 26 of them (96.2%), while there were only four informative CT angiograms (40%) out of the 10 patients in whom Elgiloy clips were used alone. In patients whom have been treated with Codman clips only one out of three patients (33.3%) was informative. When different types of aneurysm clips used in the same case the diagnostic yield of CT angiograms were informative in two out of five (40%). Our study revealed less artifacts with the titanium clips allowing adequate evaluation of the aneurysm residual, adjacent structures, parent vessels and aneurysm regrowth if present.

The quality of CTA image can be grossly affected not only by the aneurysm clip material but also by the vicinity to skull base location and by the multiplicity of the applied clips per aneurysm (Figure 3,5) because of the increased metal volume that subsequently enhanced the metal artifact produced. These artifacts appear particularly with multiple normal-sized or large clip. 9, 22)

In this study, patients in whom only one clip was sufficient to perform appropriate neck clipping, the post-operative CT angiograms were being informative in 23 out of 27 (85.2%) irrespective to the clip material, while in patients whom needed more than one clip, CT angiogram was informative to a lesser extent so that, only 10 out of 15 patients (66.7%) with 2 clips applied while none of the three patients whom needed three clips the CT Angiogram was informative. Out of 38 cases with non-skull base location of clipped cerebral aneurysm 34 (77.3 %) of post-operative CTAs were informative, while in skull base located clipped aneurysms 4 of 7 (57.1 %) only post-operative CTAs were informative

In spite of the observed tendency of better image quality between non skull base to skull base aneurysm locations, it was not statistically significant (P = .2), but this insignificant correlation might be attributed to the small number of skull base location clipped aneurysms compared to the non-skull base clipped aneurysm locations, or in general small sample number.

With technological advances in the multi-detector CT scanners and the use of narrow collimated beam aneurysm clip metal artifact could be significantly reduced and hence gives an opportunity to visualize clearly the adjacent vessels to the aneurysm clips. 11) Not only the CT machine type and protocol are responsible for the degree of aneurysm clips induced metal artifact but also, we think that number of used clips as well as the used aneurysm clips material might have a shared role. Van der Schaaf et al found that the clip site could be viewed in between the streak artifacts in the easiest way using thin-slab interactive multi-planar reformations when the window setting is being wide. Also the volume rendering could help, but maximum intensity projections (MIP) only increase the artifact and hence should not be used in the clip site evaluation. 7) In our study, we successfully reduced image artifacts by multiple ways: MPR usage, increase KVp. We used multi-planar reformat for better evaluation of aneurysm clip status, residual aneurysm and adjacent vasculature.

The introduction of 3D CT angiography offers visualization of the intracranial vasculature without the need to perform DSA with its known associated risk potentials. Titanium clips showed significant artifact reduction observed in 3D CT angiography when compared to cobalt or stainless-steel alloys. 7, 20) In our study we had 3D reformat in all the cases, we found that the usage of 3D reformats markedly improved the evaluation of the aneurysm neck, residual (if present) and adjacent structures.

Using high kVp in scanning results in less artifact when compared to that with low kVp; however, there is a decrease at higher kVp in the attenuation of iodine- containing contrast, and so arterial enhancement. This drawback could be compensated for by increasing the iodine concentration to 350 up to 400 mg I/mL 7, 23) Scanning patients with 140 kVp and 370 mg I/mL led to a better visualization of the vessels adjacent to the clip site.7) In our study we used higher KV than 120 (sometimes up to 140KVp).

The Elgiloy and Codman made clips showed metallic artifacts in CTA more than those with titanium in similar locations; never the less the vicinity to bone (skull base locations) as in PcomA or ophthalmic segment aneurysms both showed less diagnostic yield and even can miss residual aneurysm filling that can be detected only with DSA but yet not statistically significant results.

Limitation of the study: limited number of cases, not all the cases could be followed by both CTA and DSA at a time as well as any of them for a long period enough to verify the presence of recurrence/regrowth of cerebral aneurysms, if any.

CONCLUSIONS

Titanium made aneurysm clips showed less metallic artifacts and can increase the diagnostic yield and accuracy of CTA follow up after aneurysm clipping specially when being away from skull base locations.

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