

# The Results of Serial Dynamic Enhanced Computed Tomography in Patients With Carotid-Cavernous Sinus Fistulas

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**Purpose:** To assess serial dynamic enhanced computed tomography (serial DE-CT) as a diagnostic tool for carotid-cavernous sinus fistula (CCF).

**Methods:** Serial DE-CT was performed in seven patients (ages 31–74) with CCF. Contrast material was injected intravenously at a dose of 60 mL with an injection speed of 4 mL per second. Serial axial images of the cavernous sinus were undertaken every 3 seconds using a helical computed tomography system. This relatively low-risk technique provides direct evidence of the arteriovenous shunt in the cavernous sinus.

**Results:** In early imaging after the injection, enhancement of the cavernous sinus on the side of the CCF was noted at the arterial phase in all patients, whereas early enhancement of the cavernous sinus was not observed on the contralateral uninvolved side.

**Conclusions:** These findings suggest the usefulness of serial DE-CT as a diagnostic tool for the initial diagnosis of both high- and low-flow CCFs. **Jpn J Ophthalmol 1999;43:559–564** © 1999 Japanese Ophthalmological Society

**Key Words:** Carotid-cavernous sinus fistula, cavernous sinus, serial dynamic enhanced computed tomography.

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## Introduction

Carotid-cavernous sinus fistula (CCF) is an acquired pathological shunt from the carotid artery into the cavernous sinus.<sup>1</sup> The main symptoms and signs are usually ophthalmic, including blurred vision, orbital pain, diplopia, proptosis, conjunctival congestion, chemosis, dilatation of the retinal vein, retinal hemorrhage, and elevated intraocular pressure.<sup>1</sup> CCFs are classified as high- or low-flow fistulas according to the velocity of blood flow through the shunt.<sup>2</sup> Diagnosis of a high-flow fistula is relatively easy because of typical clinical signs. However, clinical symptoms and signs of low-flow fistulas are sometimes very mild, making a diagnosis difficult.

Selective cerebral angiography is an essential tool for the diagnosis and therapeutic determination of

CCF, and provides a complete analysis of the anatomy and hemodynamics of a CCF.<sup>3–5</sup> However, selective cerebral angiography is invasive and carries a small but real morbid risk. Orbital ultrasonography, computed tomography (CT) scanning, and magnetic resonance imaging (MRI) can reveal a dilatation of the superior ophthalmic vein (SOV), enlargement of extraocular muscles, or convex bulging of the cavernous sinus in patients with CCFs.<sup>1,6,7</sup> These signs could be indirect evidence of CCF, but not specific for the diagnosis of CCF. Pneumotometry may suggest the presence of a CCF with the finding of increased intraocular pulse pressure.<sup>8</sup> Doppler ultrasonography demonstrates the arterialized blood flow rate in the SOV.<sup>9</sup> However, these signs would be very mild in patients with low-flow CCFs, and techniques for obtaining clear data are relatively difficult. MR angiography can show the high-speed blood flow in the arterialized veins caused by CCF,<sup>1</sup> but does not provide direct evidence of pathological shunting from the carotid artery to the cavernous sinus.

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In this study, we performed serial dynamic enhanced computed tomography (serial DE-CT) scanning of the cavernous sinus in seven patients with CCFs, in whom the diagnosis was finally confirmed by selective cerebral angiography. Serial DE-CT of the cavernous sinus provides direct evidence of pathological shunting from the carotid artery to the cavernous sinus. Results of serial DE-CT in patients with CCFs have not been reported yet. We report results of serial DE-CT and selective cerebral angiography in patients with CCF.

### Materials and Methods

The subjects of our study were seven consecutive patients (age range, 31-74 years) with CCF, who were examined at Sapporo Medical University Hospital between September 1995 and February 1998. The chief complaints of these patients were proptosis, conjunctival congestion, or diplopia. CCF was finally diagnosed by selective cerebral angiography in all patients. Of the seven patients, two had high-flow

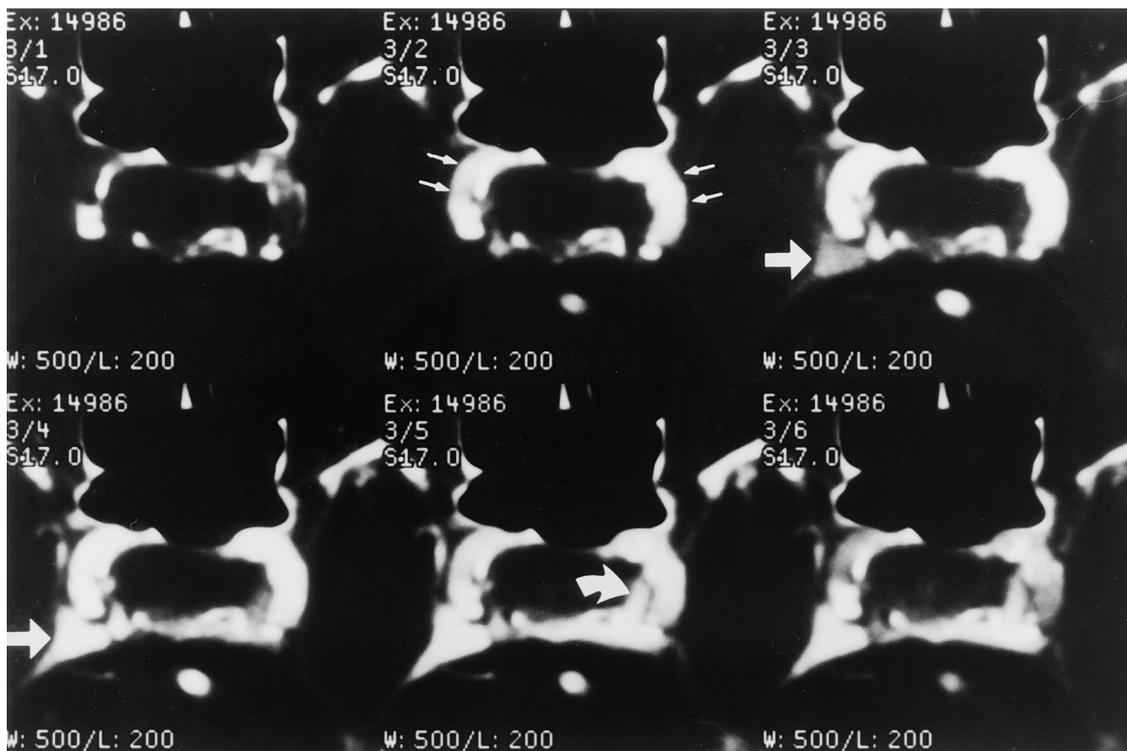
fistulas, and the others had low-flow fistulas. The direct high-flow fistulas were due to trauma or a ruptured aneurysm. The CCF in each patient was classified according to the guidelines of Barrow et al<sup>2</sup> into type A (communication between internal carotid artery and cavernous sinus), type B (communication between meningeal branches of internal carotid artery and cavernous sinus), type C (communication between meningeal branches of external carotid artery and cavernous sinus), and type D (communication between meningeal branches of both internal and external carotid arteries and cavernous sinus). Type A represents a high-flow CCF, and types B-D represent low-flow CCFs. The clinical characteristics and the type of CCF in the seven patients are shown in Table 1. Types C and D were noted in two patients each, whereas one patient had type B fistulas.

In all patients, plain axial CT along Reid's baseline at 3-mm-thick slices was performed initially, and space-occupying lesions were ruled out. One slice level, in which the cavernous sinus could be clearly observed, was selected in each patient. This slice

**Table 1.** Clinical Characteristics of Seven Patients With Carotid-Cavernous Sinus Fistulas (CCF)

Patient No.	Age (y)	Gender	Clinical Signs	Findings of Selective Cerebral Angiography	Findings of DE-CT and Conventional CT
1	32	M	Conjunctival congestion, chemosis, proptosis, bruit, ocular hypertension, retinal vein dilation, oculomotor and abducens nerve paresis	CCF, type A	Dilatation of SOV, early staining of cavernous sinus
2	31	F	Subconjunctival hemorrhage, proptosis, ocular hypertension, retinal vein dilatation, bruit, oculomotor, trochlear and abducens nerve paresis	CCF, type A, with aneurysm	Dilatation of SOV, aneurysm, early staining of cavernous sinus
3	55	F	Arterialized conjunctival vessels, mild retinal vein dilatation, proptosis, ocular hypertension	CCF, type B	Dilatation of SOV, early staining of cavernous sinus
4	74	F	Arterialized conjunctival vessels, proptosis, retinal vein dilatation, mild oculomotor nerve paresis, ocular hypertension	CCF, type C	Dilatation of SOV, early staining of cavernous sinus
5	68	M	Arterialized conjunctival vessels, proptosis, retinal vein dilatation, mild oculomotor nerve paresis, ocular hypertension	CCF, type C	Dilatation of SOV, early staining of cavernous sinus
6	50	F	Arterialized conjunctival vessels, proptosis, retinal vein dilatation, retinal hemorrhage, ocular hypertension	CCF, type D with cavernous sinus thrombosis	Dilatation of SOV, no enhancement effect of cavernous sinus
7	72	F	Arterialized conjunctival vessels, proptosis, ocular hypertension, mild oculomotor nerve paresis	CCF, type D	Dilatation of SOV, early staining of cavernous sinus

DE-CT: dynamic enhanced computed tomography, M: male, SOV: superior ophthalmic vein, F: female.



**Figure 1.** Example of serial dynamic enhanced computed tomography of cavernous sinus at level of sella turcica in patient 4 with type C carotid-cavernous sinus fistula on right side. Serial axial images around sella turcica at intervals of 3 seconds are arranged from upper left (10 seconds after rapid intravenous injection of enhanced material) to bottom right (25 seconds after injection). Small arrows indicate internal carotid arteries. Large arrows indicate early staining of right cavernous sinus. Curved arrow indicates staining of left cavernous sinus.

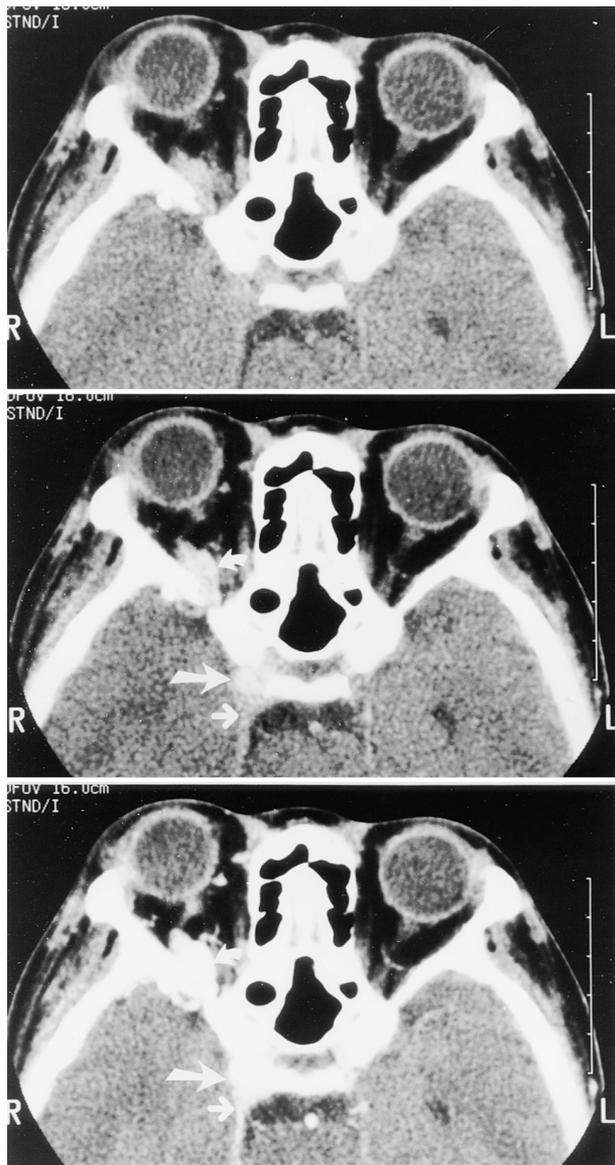
level was near the level of the sella turcica in all patients. Contrast material was injected intravenously at a dose of 60 mL with an injection speed of 4 mL per second. Serial axial images of the cavernous sinus at the selected level in 3-mm-thick slices were undertaken every 3 or 5 seconds, starting 10 seconds after the onset of contrast material injection, using a helical CT system. Fifteen sequential axial images were obtained. After the serial DE-CT, 40 mL of contrast material was again injected over 20 seconds, and serial axial images of the orbit at 3-mm-thick slices were taken to clarify the dilatation of the SOV.

### Results

Patients 1 and 2 with type A CCF exhibited severe proptosis, chemosis, subconjunctival hemorrhage, dilatation of the retinal veins, ocular hypertension, ocular motility disorders, and bruit, making clinical diagnosis easy in these patients. Patients 3 through 7 with low-flow CCFs (types B–D) exhibited arterialized conjunctival vessels and ocular hypertension.

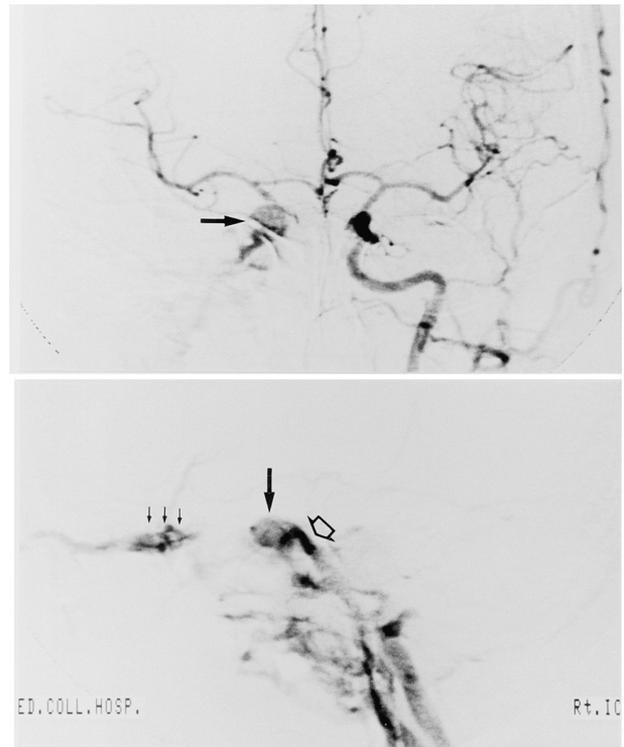
However, proptosis, dilatation of the retinal veins and ocular motility disorders were very mild in these patients. No bruit was noted. Orbital congestion and neurological signs were weak in the patients with low-flow CCFs. Selective cerebral angiography and embolization of pathological shunts were finally performed in all patients.

In conventional CT, all patients exhibited dilatation of the SOV on the side of the CCF (Table 1). In serial DE-CT, early staining of the cavernous sinus in the arterial phase was observed on the side of CCF in all patients except patient 6, who had cavernous sinus thrombosis in association with CCF. The internal carotid arteries were stained from 13–15 seconds after the onset of the injection. The cavernous sinus on the side of the CCF was markedly stained at the onset of staining of the internal carotid artery in patients with types A and B CCF. The onset of staining of type C CCF started 3 seconds after the onset of staining of the internal carotid artery (Figure 1). The onset of staining of the cavernous sinus on the intact side occurred at 19 to 22 seconds. Patient 2



**Figure 2.** Example of serial dynamic enhanced computed tomography of cavernous sinus in patient 2 with type A carotid-cavernous sinus fistula after intracavernous aneurysm. Serial axial images at intervals of 3 seconds are arranged from top (10 seconds after rapid intravenous injection of enhanced material) to bottom (16 seconds after the injection). Large arrows indicate aneurysm. Small arrows indicate early staining of cavernous sinus. Curved small arrow indicates staining of superior ophthalmic vein.

had an aneurysm of the internal carotid artery in the cavernous sinus. In serial DE-CT, the aneurysm, the cavernous sinus and the SOV were stained at the same phase (Figure 2). Selective cerebral angiography revealed the aneurysm in the C3 portion of the right

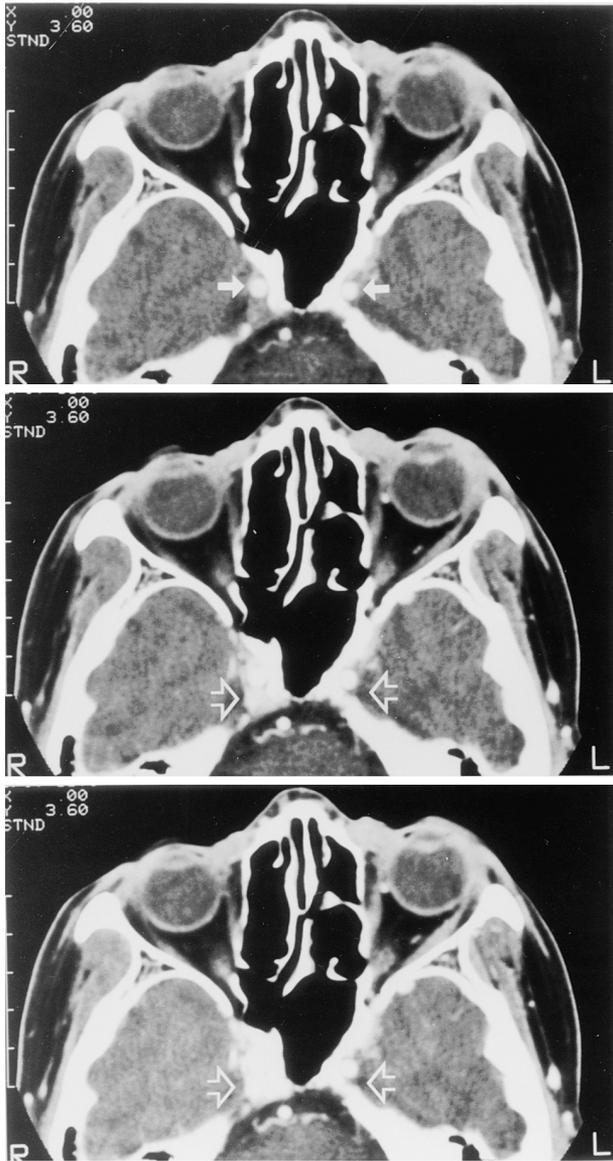


**Figure 3.** Anterior (upper panel) and lateral (lower panel) views of selective cerebral angiography of internal carotid artery indicating aneurysm in C3 portion of right internal carotid artery associated with type A carotid-cavernous sinus fistula in patient 2. Large arrows in upper and lower panels indicate aneurysm. Small arrows in lower panel indicate superior ophthalmic vein. Open arrow in lower panel indicates inferior petrosal sinus.

internal carotid artery associated with the type A CCF in this patient (Figure 3). In patient 6, the left cavernous sinus was not stained even at the venous phase (Figure 4). Selective cerebral angiography revealed CCF, type D, with cavernous sinus thrombosis (Figure 5). The meningeal branches of external and internal carotid arteries were shunting to the superior ophthalmic vein and the petrosal sinus, respectively. The central portion of the cavernous sinus was obstructed by a thrombosis.

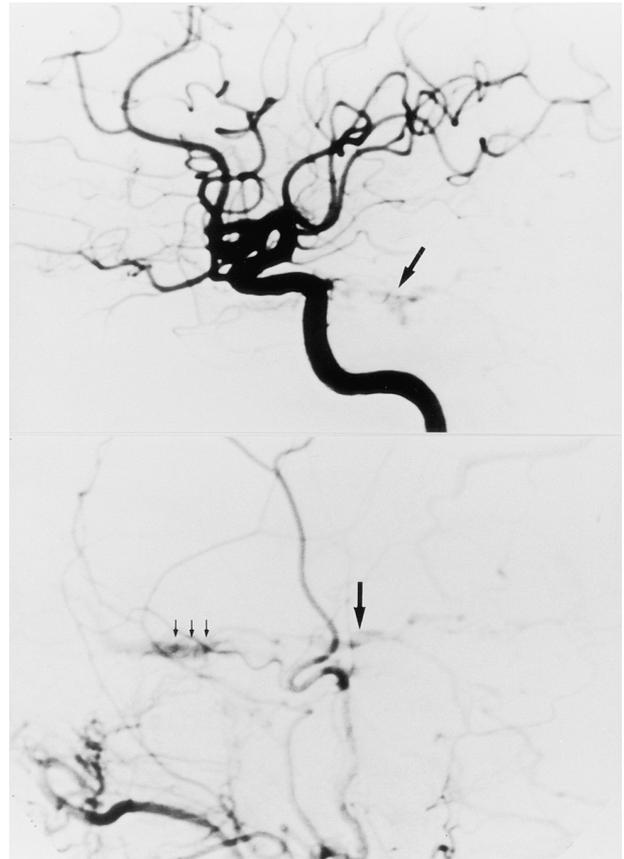
### Discussion

This study indicated that axial serial DE-CT of the cavernous sinus provided us direct evidence of pathological shunting from the carotid artery to the cavernous sinus in patients with both high- and low-flow CCFs, although the shunt vessels were not revealed with serial DE-CT. These findings indicated the usefulness of serial DE-CT as a diagnostic tool



**Figure 4.** Example of serial dynamic enhanced computed tomography of cavernous sinus in patient 6 with type D carotid-cavernous sinus fistula and left cavernous sinus thrombosis. Serial axial images at intervals of 5 seconds are arranged from top (15 seconds after rapid intravenous injection of enhanced material) to bottom (25 seconds after injection). Small arrows indicate internal carotid arteries. Open arrows indicate staining of right cavernous sinus. There was no staining of left cavernous sinus in venous phase.

for the initial diagnosis of CCF. Serial DE-CT is a relatively safe procedure even in older patients, in contrast to selective cerebral angiography, although selective cerebral angiography is needed for the final decision on therapeutic intervention.



**Figure 5.** Lateral view of selective cerebral angiography of left internal (upper panel) and external (lower panel) carotid arteries indicating pathological shunting from meningeal branches of external and internal carotid arteries to superior ophthalmic vein and petrosal sinus in patient 6. Large arrows indicate petrosal sinus. Small arrows in lower panel indicate superior ophthalmic vein.

The differential diagnosis for a patient with a congested orbit must be considered in those patients who develop CCFs. Orbital inflammatory disease such as dysthyroid orbitopathy or orbital cellulitis, or orbital tumor can also cause a congested orbit.<sup>1</sup> Imaging studies can aid in the differential diagnosis in patients with suspected CCF. Clinical symptoms and signs of low-flow fistulas are sometimes very mild, and many low-flow CCFs close spontaneously.<sup>2,10-12</sup> CT must be included in the routine examination of a patient with a congested orbit.

Serial DE-CT after conventional CT can reveal pathological shunting from the carotid artery to the cavernous sinus as well as rule out orbital inflammatory disease and orbital tumor. Intravenous digital subtraction angiography has been used for evaluat-

ing CCF.<sup>13</sup> This technique is almost as safe as serial DE-CT, but it has poor resolution and therefore its usefulness in the diagnosis of CCF is limited.<sup>7</sup> In contrast, serial DE-CT is very convenient. If neither space-occupying lesions nor inflammatory orbital disease are observed by conventional CT in a patient with a congested orbit, conventional CT may be followed up with serial DE-CT. When pathological shunts are noted by serial DE-CT, selective cerebral angiography should be performed for deciding on therapeutic intervention.

In addition, serial DE-CT provides information about the hemodynamics of the cavernous sinus in patients with cavernous sinus thrombosis as well as CCF. In patient 6, the left cavernous sinus was not stained even at the venous phase in serial DE-CT, suggesting cavernous sinus thrombosis. Patients with cavernous sinus thrombosis exhibit ocular signs compatible with CCF, and differential diagnosis is required.<sup>14</sup> Other diagnostic techniques like orbital ultrasonography, conventional CT and MRI do not provide information confirming cavernous sinus thrombosis.

The cavernous sinus was observed on images at the level of the sella turcica in all the patients in this study. This is compatible with the anatomical findings in a previous study.<sup>15</sup> Although bulging of the cavernous sinus was not observed in any of the patients in this study, early staining of the posterior part of the cavernous sinus was always observed. In type C CCF, the onset of early staining of the cavernous sinus was delayed to shortly after the onset of staining of the internal carotid artery. In types A and B CCF, staining of the cavernous sinus started at the same time as that of the internal carotid artery. This delay is assumed to result from the absence of communication between the internal carotid artery and the cavernous sinus in type C CCF.

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