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Original Article

Imaging study on the optic canal using sixty four-slice spiral computed tomography

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Abstract: Background: Rapid advances in multislice computed tomography (MSCT) technology facilitate accurate clinical imaging. The newly developed 64-slice CT increases temporal and spatial resolution efficiently. Purpose: The purpose of this study is to evaluate the application of 64 slice spiral computed tomography (CT) on the imaging of the normal optics canal. Methods and materials: 100 healthy adults were investigated using 64 slice spiral CT. The optics canal was scanned, reconstructed and examined. Results: Among the four walls of the optic canal, the medial wall is the longest one. The upper wall and outer wall are inferior to the medial wall while the inferior wall is the shortest one. All the data accomplished by the 64 slice CT was consistent with the results of previous reports using other methods. Conclusion: The results suggested that the 64 slice spiral CT could be a valuable and accurate method for measuring the length of optics canal walls.

Keywords: Optic canal, CT, 64 slice spiral, imaging sectional anatomy

Introduction

Multislice computed tomography (MSCT) imaging technology has been developing rapidly recently. Rapid advances in this field have facilitated increasingly accurate clinical imaging. Four-slice, sixteen-slice and sixty four-slice CT appeared in 1998, 2001 and 2004 separately [1]. The newly developed 64-slice CT scanner provides 0.4 mm nearly isotropic voxels in a rotation time of 0.37 s. Compared with previous CT scanner types, it increases temporal and spatial resolution efficiently [2-4]. It is reported that 64-slice CT technology shows high accuracy in detecting coronary artery stenoses with more than 50% luminal narrowing [5]. It has been applied to visualize the lumen of coronary artery bypass grafts after intravenous injection of contrast agent [3, 6]. However, there are still few reports about its application in the diagnosis of the optics canal.

Optic canal (OC) is an important channel of orbital and intracranial [7]. And it also is the narrowest part which leads optic nerve to the brain. Optic nerve injuries are severe complication of the head injuries [8]. And the main treatment is still optic nerve decompression surgery. The optic canal anatomy is vital for the optic nerve decompression surgery [9, 10]. The unclear of anatomy could cause severe injuries or even lethal accident. The anatomy data of the optic canal still most relied on the autopsy. With the recent rapid development of the MSCT scanning technology, we are trying to apply this modern imaging diagnosis technology to facilitate the clinical operations. Thus, we applied isotropic scanning on the healthy volunteers using 64-slice spiral CT. The orbital apexes of the volunteers were scanned and measured after 3-dimensional reconstruction of the measurement to achieve the optic canal anatomy of the normal person accurately.

Materials and methods

Study subjects

100 patients who came to our hospital due to eye disease from the year 2009 to 2010. CT

Figure 1. CT image of the optic canal: measuring upper wall (black arrow) and inferior wall (white arrow) by sagittal reconstruction (A) and measuring inner wall (black arrow) and exterior wall (white arrow by transaxial reconstruction (B).

Table 1. Healthy adults' optic canal length of each wall

Optic canal wall	Case (N)	X ± sd (l/mm)	RSD (%)	
Left	superior wall	100	10.2 ± 0.9	9.08
	inferior wall	100	6.2 ± 0.8	13.14
	inwall	100	11.9 ± 0.9	7.49
	outer wall	100	7.7 ± 0.8	10.68
Right	superior wall	100	10.2 ± 0.9	9.12
	inferior wall	100	6.2 ± 0.8	13.20
	inwall	100	11.9 ± 0.9	7.34
	outer wall	100	7.7 ± 0.8	9.98

scanning showed that their orbits structure had no abnormalities. The 100 volunteers included 50 male and 50 female patients, aged 25-30 years. All volunteers were selected through a strict physical examination to exclude any possible diseases that could lead to changes in the anatomy of the orbital cavity.

Methods

Light Speed 64-slice spiral CT (GE Company, USA) was applied on transaxial isotropic scanning using canthomeatal line as the baseline. Continuous scanning started from the inferior orbital rim to the supraorbital margin level. The characters listed as following: thickness, 2.5 mm; span, 2.5 mm; scan voltage, 120 kV; current, 220 mA; matrix, 512 × 512; vision, 200 mm; scan speed, 0.6 r/s. Advantage Workstation software 4.3 of independent diagnostic workstations (reconstruction thickness: 0.625 mm) was used to do the transaxial and sagittal reconstruction of the optic canal.

The upper wall and inferior wall was measured by sagittal reconstruction while the medial and outer wall was measured by transaxial reconstruction.

Statistical analysis

SPSS 16.0 software was used for statistical analysis. The data were recorded as mean ± standard deviation (SD), all the data was evaluated using student's t-test and $P<0.5$ was considered as statistically significant.

Results

The length of the left and right sides of each optic canal wall measuring by transaxial and sagittal reconstruction

The length of left side of the upper wall is 10.06 ± 0.49 mm and right side is 10.04 ± 0.56 mm. These data shows no significant difference. The length of the left side and right side of the inferior wall is 6.23 ± 0.47 mm and 6.19 ± 0.46 mm and RSD is 13.14% and 13.20% separately. The wall's length of the left and right side of inner wall is 12.06 ± 0.31 mm and 12.04 ± 0.33 mm separately and RSD of the left side is 7.49% and that of right side is 7.34%. When it comes to exterior wall, the left and right wall's

Figure 2. Measurement of the left-right and vertical diameter and the of the nrve canal at oblique sagittal view.

length is 7.90 ± 0.42 mm and 7.89 ± 0.39 mm and RSD is 10.68% and 9.98% separately. All these data of the left and right sides did not show any significant difference (**Figure 1A** and **1B**; **Table 1**).

Measuring orbital opening and cranial opening at oblique sagittal view which is vertical perpendicular to optic canal

The length of the transversal diameter of the orbital opening is 5.18 ± 0.38 mm on the left side while that of the right side is 5.13 ± 0.38 mm. The length of the vertical diameter of the left side and right side is 6.02 ± 0.44 mm and 5.97 ± 0.42 mm separately. The transversal diameter of the orbital opening of the left side is 7.37 ± 0.39 mm and that of the right side is 7.33 ± 0.38 mm. The vertical diameter of left side is 4.97 ± 0.30 mm and that of right side is 5.01 ± 0.27 mm (**Figure 2**; **Table 2**).

The measurement of the transversal and vertical diameter of each layer of every 0.5 mm

After the reconstruction measurement at oblique sagittal view, we also measured the length of the transversal and vertical diameter of each layer of the optic canal of every 0.5 mm. Results showed that the number of layers with complete four walls is 10 to 14. And the narrowest part of optic canal is the 6-9 layers behind the orbital opening.

Discussion

Optic canal is still sticking point in the Orbital imaging examination due to its narrow diameter, deep position as well as the thin bone. The optic canal anatomy is very important for clinical surgeries like the optic nerve decompression surgery. Thus the purpose of this study is trying to measure the optic canal accurately by the modern imaging technical, in order to provide more accurate information for the clinical operation.

There are three methods for the study of the optic canal. 1) Autopsy: The optic canal was separated and then examined accurately to get the related data of the optic canal. Liu et al. used computer image analysis system to analyze the 0.5 mm serial sections of 50 wet cadaveric heads, in order to measure the structure of 36 side coronal [11]. Li et al. did the microanatomy of optic canal of 50 adult cadaveric and 20 dry skull specimen head to measure the length, diameter and the walls' thickness of the optic canal [12]. 2) The combination of the anatomy and image scan: The cadaveric head could be scanned by CT or MRI and then compared with data of autopsy. Liu et al. carried out the anatomy observation by performing axial CT scan to 33 dry skull specimens together with 10 sectional specimen of cranium [13]. Ma et al. measured the orbital apex of 30 cadaveric heads by anatomy and analyzed 9 of them by CT scan randomly, and then compared the results [14]. Daniels compared the results of the CT scan and the anatomy of the cadaveric head, and proved that the two results were very close to each other [15]. 3) Scan on the living body. Recently, similar studies have been reported but due to the limitation of the scanning equipment researchers could only draw the conclusion about how to achieve the best scanning efficacy instead of accurate measurement. Some scientists scanned the optic apex of 40 healthy adults by CT and MRI to analyze the normal imaging [16]. Results showed that CT scanning on the transaxial and coronal view could show the anatomy of the optic apex accurately. Weninger et al applied MSCT to observe the optic apex of 10 healthy volunteer [17]. Results proved that MSCT could clearly show the bone structure of the orbital apex, and 80% of the intraorbital and intracanalicular segments of optic nerve could be

Table 2. Left-right and vertical diameter of each layer of optic canal orbital aperture, cranial orifice

	Left-right diameter				Vertical diameter			
	Left		Right		Superior		Inferior	
	$\bar{x}$ ± sd (l/mm)	RSD(%)	$\bar{x}$ ± sd (l/mm)	RSD(%)	$\bar{x}$ ± sd (l/mm)	RSD(%)	$\bar{x}$ ± sd (l/mm)	RSD(%)
Orbital aperture	5.18 ± 0.38	7.38	5.13 ± 0.38	7.46	6.02 ± 0.44	7.27	5.97 ± 0.42	7.06
1 layer	5.19 ± 0.28	5.42	5.19 ± 0.28	5.45	6.00 ± 0.29	4.88	5.95 ± 0.34	5.64
2 layer	5.27 ± 0.23	4.5	5.33 ± 0.25	4.62	5.97 ± 0.31	5.20	5.99 ± 0.33	5.44
3 layer	5.27 ± 0.36	6.74	5.29 ± 0.38	7.25	5.80 ± 0.33	5.64	5.85 ± 0.33	5.70
4 layer	5.17 ± 0.46	8.93	5.23 ± 0.50	9.46	5.62 ± 0.42	7.46	5.67 ± 0.45	7.88
5 layer	5.03 ± 0.33	6.49	5.15 ± 0.38	7.34	5.46 ± 0.36	6.56	5.53 ± 0.32	5.78
6 layer	4.86 ± 0.26	5.43	4.91 ± 0.30	6.05	5.29 ± 0.34	6.43	5.31 ± 0.35	6.62
7 layer	4.91 ± 0.29	5.90	4.91 ± 0.25	5.10	5.26 ± 0.30	5.78	5.27 ± 0.30	5.73
8 layer	5.25 ± 0.50	9.60	5.25 ± 0.46	8.81	5.17 ± 0.44	8.44	5.21 ± 0.49	9.39
9 layer	5.88 ± 0.41	6.96	5.82 ± 0.39	6.66	5.17 ± 0.54	10.52	5.17 ± 0.56	10.75
10 layer	6.39 ± 0.41	6.46	6.31 ± 0.33	5.28	5.13 ± 0.48	9.27	5.16 ± 0.56	10.79
11 layer	6.75 ± 0.45	6.64	6.67 ± 0.40	5.95	5.09 ± 0.38	7.39	5.06 ± 0.43	8.50
12 layer	6.99 ± 0.38	5.42	7.06 ± 0.31	4.37	5.06 ± 0.26	5.15	5.13 ± 0.28	5.5I
13 layer	7.12 ± 0.28	3.86	7.07 ± 0.32	4.55	4.92 ± 0.38	7.67	5.00 ± 0.44	8.72
Cranial orifice	7.37 ± 0.39	5.29	7.33 ± 0.38	5.12	4.97 ± 0.30	5.98	5.01 ± 0.27	5.47

showed in the same transverse plane. Daniels et al. once used CT and MRI to scan the optic apex [18]. Results showed that the combined scan of coronal and sagittal and axial could efficiently show the structure of the optic apex. Kapur et al. reported some signs of the bones like sphenoid greater wing and pterygopalatine fossa are vital for the optic apex identification in the coronal and axial scan [19].

High resolution spiral CT has been applied in clinic due to its high space resolution and low influence of the partial volume effects. It could show the structure of bones objectively as well as the structure of the optic canal accurately. The spiral CT shows great values on anatomy relationship on random direction when it is applied together with three-dimensional reconstruction.

In this study, we used 64 spiral CT isotropic scanning on optic canal of healthy volunteers. The results we got are consistent with previous studies, which proved that the newly developed image scan technology could provide the accuracy required in clinical application [20, 21]. The method we used is obliquesagittal reconstruction in the position vertical to the optic canal. It is a brand new method and has not been reported in the previous studies. This method has an advantage in measuring the length and dimension of each wall of the optic canal and could reduce the measuring error to the lowest.

Our study shows that the inner wall is the longest one during the four walls followed by the upper wall and exterior wall, while the lower wall is the shortest. The result consists with previous report. The meaning of this study is that we achieved the accurate length of all the walls of the optical canal by three dimension reconstruction after the isotropic scan for the first time, and we proved that this advanced technology could provide personalized data and guide for the clinical operation.

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Disclosure of conflict of interest

None.

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