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The relationship between Koos classification and ADC-post-contrast signal intensity values of vestibular schwannoma - A cross sectional study

Vestibüler schwanomlarda Koos sınıflaması ile ADC-post kontrast sinyal intensite değerlerinin ilişkisi – Bir kesitsel çalışma

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Abstract

Aim: We aimed to determine the inter-observer reliability of the Koos classification and to evaluate its correlation with Apparent Diffusion Coefficiency (ADC) and post contrast signal intensity values.

Methods: Vestibular schwannomas were retrospectively scanned from picture archiving and communication system over a 4-year period. Koos grade of tumor was assessed by two radiologists blinded to the clinical and pathological data. Cohen's Kappa was used to analyse inter-observer agreement of Koos grade. The correlation between ADC, signal intensity measurements and Koos grade of tumors was analysed with Kendall's tau b correlation coefficient.

Results: Thirty three patients (21 females, mean age 52.6±16.6 years) with 34 vestibular schwannomas were included the study. The reliability analyses revealed excellent inter-observer agreement for ADC (ICC: 0.93, 95% CI: 0.87-0.97, p<0.001) and signal intensity (ICC: 0.98, 95% CI: 0.96-0.99, p<0.001) measurements. The percentage agreement for Koos grading was 97% (k= 0.96, p<0.001). A correlation was not found between the Koos grade and ADC (_τ_b: 0.18). Also signal intensity remained similar between Koos grades (p=0.125). A significant difference was found for ADC values between Koos grades (p=0.039).

Conclusion: Koos classification is a practical and useful grading system with excellent inter-observer agreement for vestibular schwannomas. ADC values differs significantly between the tumor grades, but ADC and post contrast signal intensity values have no correlation with Koos grade.

Key Words: Vestibular Schwannoma, magnetic resonance imaging, Koos classification, apperent diffusion coefficient.

Öz

Amaç: Bu çalışmada Koos sınıflamasının gözlemciler arası güvenilirliğini ve Görünür Difüzyon Katsayısı (ADC) ve kontrast sonrası sinyal intensite değerleri ile korelasyonunu değerlendirmeyi amaçladık.

Yöntemler: Hastane veri tabanından 4 yıllık süre içerisinde radyolojik raporlamada vestibuler şıvannom tanısı yer almış olan MR görüntüleri retrospektif olarak tarandı. Lezyonların Koos sınıflamasına göre derecesi, klinik ve patolojik verilere kör olan iki bağımsız radyolog tarafından değerlendirildi. Koos sınıflamasının gözlemciler arası uyumunu analiz etmek için Cohen's Kappa; ADC, sinyal intensite ölçümleri ve Koos tümör derecesi arasındaki korelasyonu değerlendirmede Kendall's tau b korelasyon katsayısı kullanıldı.

Bulgular: 34 vestibüler şıvannom, 33 hasta (21 kadın, ortalama yaş 52.6±16.6 yıl) çalışmaya dahil edildi. Güvenilirlik analizleri, ADC (ICC: 0,93, %95 GA: 0.87-0.97, p<0,001) ve sinyal intensite (ICC: 0,98, %95 GA: 0,96-0,99, p<0,001) ölçümleri için gözlemciler arası mükemmel uyum saptandı. Koos evrelendirmesiiçin değerlendiriciler arasında %97 oranında uyum saptandı (k= 0,96, p<0,001). Koos evresi ile ADC (_τ_b: 0,18) arasında bir korelasyon saptanamadı. Ayrıca sinyal intensitelerinin farklı Koos evreleri arasında değişmediği saptandı (p=0,125). Ancak Koos evreleriarasında ADC değerleri açısından anlamlı fark olduğu saptandı. (p=0,039).

Sonuç: Koos sınıflaması, vestibüler şıvannomlar için mükemmel gözlemciler arası uyuma sahip, pratik ve kullanışlı bir evrelendirme sistemidir. ADC değerleri ile tümör evreleri arasında önemli ölçüde farklılık izlenirken, ADC ve kontrast sonrası sinyal intensite değerlerinin Koos derecesi ile korelasyonu yoktur.

Anahtar Kelimeler: Vestibular schwannom, manyetik rezonans görüntüleme, Koos sınıflaması, görünür difüzyon katsayısı

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Introduction

Vestibular schwannomas (VS) are the most common cerebellopontine angle (CPA) tumors and the third most common intracranial benign tumors [1, 2]. Sensorineural hearing loss and tinnitus are the most common clinical symptoms, while vertigo, 5th and 7th cranial nerve neuropathies, brain stem compression findings and hydrocephalus are other symptoms [2, 3]. Histopathological confirmation is not always required for VSs because these lesions are detected with a great accuracy in MRI [2, 4]. Lesions have an intracanalicular component and enlarge the internal acoustic canal. Generally, they are iso/hypointense on T1-weighted (T1W) images and hyperintense on T2-weighted images (T2W), with homogeneous marked enhancement [4]. Cystic and hemorrhagic changes are seen in large lesions, while absence of calcification is typical [2]. T1W images are the best for post-operative evaluation of recurrence or residue, T2W images are important for differential diagnosis of the other conditions that affect the brain stem, fast imaging employing steady-state acquisition (FIESTA)/constructive interference in steady state (CISS) sequences are standart for 7th and 8th nerve assessment, post-contrast images are also indispensable for temporal imaging for differential diagnosis of masses [2]. CT is used to evaluate the petrous bone for the decision of surgical approach, but is a limited imaging method for internal acoustic canal [5].

Surgery and radiotherapy are the treatment options, also observation may be choosen for VSs [6]. Although decision of treatment or observation is determined by factors such as the patient's symptoms and comorbidities, the Koos classification is the most widely used grading system for these tumors [2]. Koos et al. had classified these tumors based on hearing protection after surgery and also defined subgroups according to the position of the cochlear nerve and evaluated the neurotopographic response [7]. Reliability [8], validity [8], response to stereotactic radiosurgery and radiotherapy according to this classification [9, 10] were previously evaluated. Reliability of apparent diffusion coefficient (ADC) and signal intensity (SI) according to tumor grade have not been well studied. This study evaluates ADC and SI measurements between VS grades according to Koos classification and also the inter-observer reliability of Koos classification.

Material and methods

This cross-sectional study was approved by the university ethics committee (approval ID: 2021/0397). The records of the reports of patients who underwent contrast enhanced temporal MRI between 2017 and 2021 were retrospectively scanned. Research from the reports was conducted with the search of using keywords of ‘vestibular schwannoma’, ‘cerebellopontine angle tumor’ and ‘acoustic neuroma’. Patients having tumor which have compatible features with VS in CPA and internal acoustic canal were evaluated. MRI exams with diffusion weighted images, ADC maps and post contrast sequences with adequate image quality were included the study. Images with inadequate quality for assessment and tumors which have incompatible features with VS were excluded from the study.

MR imaging parameters and evaluation

The side, maximum diameter of tumor, ADC (Fig.1), post contrast SI values (Fig.2), Koos grade of tumor were assessed by two radiologists blinded to the clinical and pathological data. According to Koos classification VSs are evaluated as; grade I (Fig.3); small intracanalicular tumor, grade 2 (Fig.4); small tumor with protrusion into the cerebellopontine angle but no contact with the brainstem, grade 3 (Fig.5); tumor occupying the cerebellopontine cistern with no brainstem displacement and grade IV (Fig.6); large tumor with brainstem and cranial nerve displacement [7].

All MRIs performed with General Electric Signa Excite 1.5 Tesla MRI device. T1 and T2-weighted sequences with a 3 mm slice thickness, 3D-FIESTA sequence with 0.5 mm slice thickness, also fluid-attenuated inversion recovery and diffusion-weighted sequence images were obtained. Post contrast images were obtained after 0.2 mL/kg gadolinium injection.

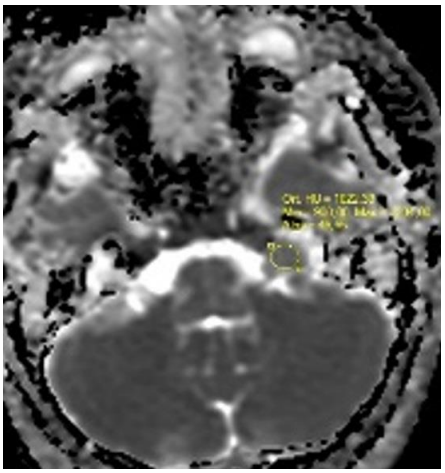

Figure 1: ADC measurement with region of interest in a left sided Koos grade 2 schwannoma.

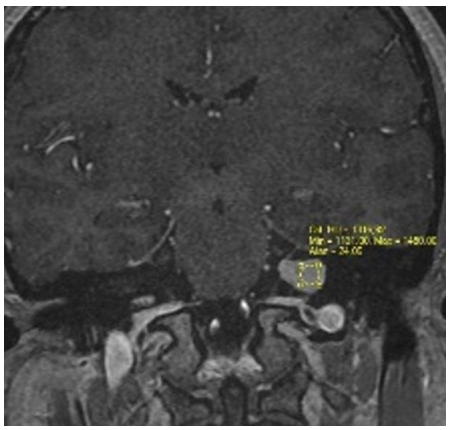

Figure 2: Post contrast signal intensity measurement in a left sided Koos grade 2 schwannoma.

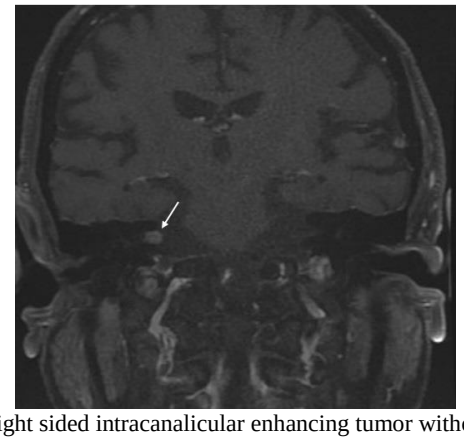

Figure 3: Right sided intracanalicular enhancing tumor without extension to cerebellar cistern (arrow); Koos grade 1.

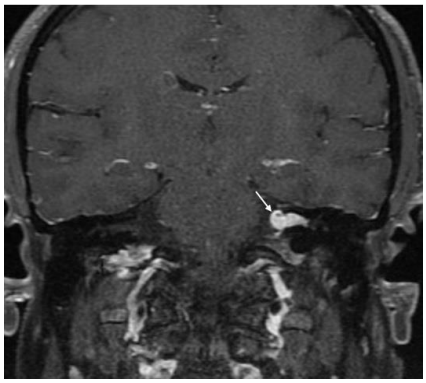

Figure 4: Left sided tumor with extension to cerebellar cistern, there is no contact with brain stem (arrow); Koos grade 2.

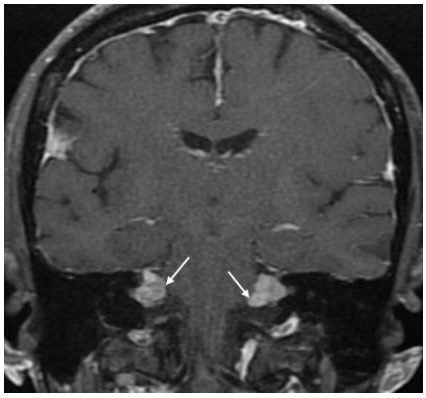

Figure 5: In a patient with NF type 2 bilateral tumors with marked enhancement, lesions are contacting brain stem but there is no compression (arrows); Koos grade 3.

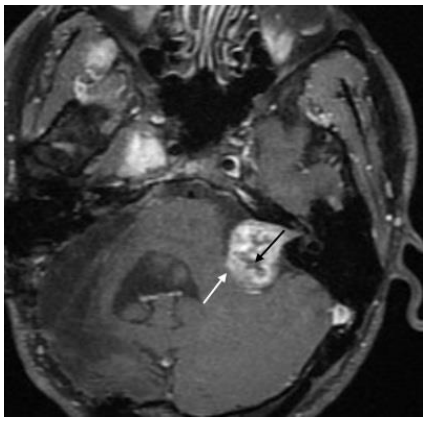

Figure 6: In another patient with NF type 2 left sided tumor with evidence of brain stem compression (white arrow), there is cystic changes in the center of the lesion (black arrow); Koos grade 4.

Statistical analysis

Data were analyzed using SPSS software (ver. 26.0; IBM Corp., Armonk, NY, USA). Cohen's Kappa was used to analyse inter-observer agreement of Koos grade. Values ≤ 0 as indicating no agreement and 0.01–0.20 as none to slight, 0.21–0.40 as fair, 0.41– 0.60 as moderate, 0.61–0.80 as substantial, and 0.81–1.00 as almost perfect agreement. Kendall's tau b correlation coefficient was used to analyse correlation between ADC, SI measurements and Koos grade of tumors (p values <0.01 were considered to indicate statistical significance).

Results

Thirty three patients [21 (61.8 %) females, mean age 52.6±16.6 years] with 34 VSs were included the study. Seventeen of the tumors were right sided and the remaining were left sided. There were bilateral schwannomas in a patient with a diagnosis of Neurofibromatosis type 2. The mean of the maximum tumor diameter was 15.03±7.13 mm. The means of whole tumor ADC and SI values were 1402±363 and 1400±512, respectively (Table 1). The frequencies for each tumor grade from 1 to 4 were, 3 (8.8%), 13 (38.2%), 9 (26.5%), and 9 (26.5), respectively (Table 2). The reliability analyses revealed excellent inter-observer agreement for ADC (ICC: 0.93, 95% CI: 0.87-0.97, p<0.001) and SI (ICC: 0.98, 95% CI: 0.96-0.99, p<0.001) measurements. The percentage agreement for tumor grading was 97%, with only one Grade 3 tumor being judged as Grade 4 by the second reader (Cohen's Kappa 0.96, p<0.001). The maximum size (p<0.001) and ADC values (p=0.039) differed significantly between the tumor grades, however, the SI values remained similar (p=0.125) (Table 2). A correlation was not found between the tumor grade and ADC values (Kendall's tau b correlation coefficient: 0.18).

Table 1: Summary of quantitative parameters.

	Size (mm)	ADC (mm^2/s) observer 1	ADC (mm^2/s observer 2	SI observer 1	SI observer 2
Minimum	3	851.0×10^{-6}	838.0	492.0	482.0
Maximum	32	2309.0×10^{-6}	2193.0	2650.0	2619.0
Median	15	1349.0×10^{-6}	1329.5	1498.0	1411.0

ADC: apperent diffusion coefficient, SI: signal intensity

Discussion

This study reports a perfect inter-observer agreement for Koos classification. ADC values differed significantly between Koos grade of VSs, however ADC or SI values were not correlated with Koos grades. According to our knowledge this is the first study that investigates correlation of Koos classification and measurable MRI parameters such as post contrast signal intensity and ADC.

Guidelines offers observation for Koos grade I-II asymptomatic tumors, stereotactic radiosurgery for grade I-II symptomatic tumors and surgery or radiosurgery for grade III-IV tumors [2]. Particularly, Koos grade IV is important in terms of life-threatening brain stem compression and the only treatment option is surgery [2]. The size of the tumor is also important for the post-surgical persistence of facial paralysis which varies between 3 and 46% [11]. The part of the tumor is in the acoustic canal, size of tumor, and which nerve components it affects are the major in determining the surgical method and access. Therefore, MRI plays a big role for guidance the surgery. Koos classification has been widely adopted in terms of surgery and has been the subject of many clinical-surgical correlation studies [7, 9, 12, 13]. Although the classification is completely based on radiologic featured, there are not many radiological studies on this subject.

Table 2: Distribution of schwannomas according to Koos grades and size, ADC and signal characteristics

	Koos grade				
	1	2	3	4	p
Number of patients, n (%)	3 (8.8%)	13(38.2)	9(26.5)	9(26.5)	
Size (mm)	3	10.5	16	23.5	<0.001
ADC observer 1	1531±443	1330±359	1215±319	1631±317	0.039
ADC observer 2	1506±407	1304±337	1228±255	1595±309	0.053
SI observer 1	720±72	1360±537	1598±505	1542±384	0.125
SI observer 2	734±15	1368±532	1529±513	1503±375	0.117

ADC: Apperent diffusion coefficiency, SI:Signal intensity

Idea in the evaluation of ADC and signal intensity values; it was thought that the water content and molecular structure of the growing tumor could be reflected in the measurable values. Size measurement can be misleading due to the different intracanalicular and cisternal components of the tumor and volumetric measurements are required. It is also known that after radiotherapy, there may be a temporary pseudo-size increase secondary to edema [14]. The hypothesis this study based on was; if ADC and/or signal intensity is associated with tumor grade, these parameters can be used for grading and follow-up of VSs. Knugelis KE. et al. reported that VSs, have between 1006-1563 × 10−6 mm2/s ADC values have worser facial nerve outcome after surgery [13]. Also ADC was reported to be useful in differential diagnosis of CPA schwannoma and meningiomas [15]. In current study ADC values showed a statistically significant difference between tumor grades. The reason for the lack of correlation between ADC and grade, may be the small number of patients and the different distribution of the tumor grades.

In previous studies some authors reported T2 signal intensity had association with soft tumor consistency and better facial nerve outcome although not statistically significance had been found [12] while some authors found no association [13]. Recent studies are generally focused on surgical planning, differential diagnosis of CPA tumors and post-operative facial nerve outcome [12, 13, 16]. In current study surgical results and facial nerve outcome were not assessed. Because, the main purpose was to correlate the grade with MRI in the patients in observation and candidate for surgery.

The main limitation of this study was the limited number of patients. And the second limitation was the diagnosis of tumors was not confirmed histo-pathologically.

In conclusion, Koos classification is a practical and useful grading system with excellent inter-observer aggreement for VSs. ADC values differs significantly between the tumor grades, but not correlated with grade. Therefore, it is not yet possible to say that ADC may be used in grading VSs. Nevertheless, it is a promising parameter in surgical planning, approach and predicting patient outcome. Future prospective studies with large patient groups are needed.

References

1. Lin D, Hegarty JL, Fischbein NJ, Jackler RK. The prevalence of "incidental" acoustic neuroma. Arch Otolaryngol Head Neck Surg. 2005;131:241-4.
2. Goldbrunner R, Weller M, Regis J, Lund-Johansen M, Stavrinou P, Reuss D. et al. EANO guideline on the diagnosis and treatment of vestibular schwannoma. Neuro Oncol. 2020;22:31-45.
3. Evans DG, Moran A, King A, Saeed S, Gurusinghe N, Ramsden R. Incidence of vestibular schwannoma and neurofibromatosis 2 in the North West of England over a 10-year period: higher incidence than previously thought. Otol Neurotol. 2005;26:93-7.
4. Singh K, Singh MP, Thukral C, Rao K, Singh K, Singh A. Role of magnetic resonance imaging in evaluation of cerebellopontine angle schwannomas. Indian J Otolaryngol Head Neck Surg. 2015;67:21-7.
5. De Foer B, Kenis C, Van Melkebeke D, Vercruysse JP, Somers T, Pouillon M. et al. Pathology of the vestibulocochlear nerve. Eur J Radiol. 2010;74:349-58.
6. Leon J, Lehrer EJ, Peterson J, Vallow L, Ruiz-Garcia H, Hadley A. et al. Observation or stereotactic radiosurgery for newly diagnosed vestibular schwannomas: A systematic review and meta-analysis. J Radiosurg SBRT. 2019;6:91-100.
7. Koos WT, Day JD, Matula C, Levy DI. Neurotopographic considerations in the microsurgical treatment of small acoustic neurinomas. J Neurosurg. 1998;88:506-12.
8. Erickson NJ, Schmalz PGR, Agee BS, Fort M, Walters BC, McGrew BM. et al. Koos Classification of Vestibular Schwannomas: A Reliability Study. Neurosurgery. 2019;85:409-414..
9. Rueß D, Pöhlmann L, Grau S, Hamisch C, Hoevels M, Treuer H. et al. Outcome and toxicity analysis of single dose stereotactic radiosurgery in vestibular schwannoma based on the Koos grading system. Sci Rep. 2020;10:930
10. Régis J, Carron R, Moucharrafien S, Delsantin C, Porcheron D, Thomassin JM. et al. Radiochirurgie et radiothérapie stéréotaxique des schwannomes vestibulaires [Role of radiosurgery and stereotactic radiotherapy in the management of vestibular schwannomas]. Cancer Radiother. 2012;16 Suppl:S70-8.
11. Morton RP, Ackerman PD, Pisansky MT, Krezalek M, Leonetti JP, Raffin MJ. et al. Prognostic factors for the incidence and recovery of delayed facial nerve palsy after vestibular schwannoma resection. J Neurosurg. 2011;114:375-80
12. Copeland W, Hoover J, Morris J, Driscoll C, Link M Use of preoperative MRI to predict vestibular schwannoma intraoperative consistency and facial nerve outcome. J Neurol Surg B Skull Base. 2013;74:347–350.
13. Kunigelis KE, Hosokawa P, Arnone G, Raban D, Starr A, Gurau A. et al. The predictive value of preoperative apparent diffusion coefficient (ADC) for facial nerve outcomes after vestibular schwannoma resection: clinical study. Acta Neurochir (Wien). 2020;162:1995-2005.
14. Lin EP, Crane BT. The Management and Imaging of Vestibular Schwannomas. AJNR Am J Neuroradiol. 2017;38:2034-43.
15. Xu XQ, Li Y, Hong XN, Wu FY, Shi HB. Radiological indeterminate vestibular schwannoma and meningioma in cerebellopontine angle area: differentiating using whole-tumor histogram analysis of apparent diffusion coefficient. Int J Neurosci. 2017;127:183-90.
16. Huang CF, Chiou SY, Wu MF, Tu HT, Liu WS, Chuang JC. Apparent diffusion coefficients for evaluation of the response of brain tumors treated by Gamma Knife surgery. J Neurosurg. 2010;113 Suppl:97-104.