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Application of Working Memory Computerized Test (WMCT) for Working Memory Deficit in Patients with Parkinson Disease

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Authors' contributions

This work was carried out in collaboration between all authors. Author A. Zarghi designed the study, wrote the protocol, and wrote the first draft of the manuscript. Author A. Zali managed the literature searches, analyses of the study performed the spectroscopy analysis and authors FA, SM and NB managed the experimental process and author A. Zarghi identified the species of plant. All authors read and approved the final manuscript.

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ABSTRACT

Introduction: This study deals with the study of memory rehabilitation in patients with Parkinson's disease. Measures included systematic rehabilitation techniques for the recovery of symptoms and had no errors. However, issues related to the design and implementation of effective, are not clear and require further study. The purpose of this study was to evaluate cognitive function in PD patients after the rehabilitation of working memory.
Methods: The outline of this study was cross-sectional with simple random sampling. According to the pilot study was the sample size n = 120 and n = 60 in each sex. Initially, patients were examined by a neurologist and psychiatrist. Consent form was completed after the final diagnosis. A computerized test of working memory rehabilitation was administered. Rehabilitation

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computerized test was done in 15 minutes to prevent fatigue effect. Information entered in the software $SPSS_{18}$. And they were analyzed using descriptive statistics and Pearson correlation test and t-test.
Results: There were significant differences in all variables of test in patients with Parkinson's disease before and after rehabilitation. And after rehabilitation has risen Memory span percent.
Conclusion: In patients with Parkinson's disease have shown favorable results after rehabilitation with this test.

Keywords: Neuro-cognitive; assessment; rehabilitation.

1. INTRODUCTION

Working memory is a theoretical concept in neuroscience and cognitive psychology. The studies of Neuroscience have shown the relationship between working memory, learning and attention. There are theories regarding the theoretical structure of working memory indicating that certain parts of the brain are involved in working memory. The studies have determined that the areas of the brain frontal cortex, parietal cortex, anterior cingulate, and parts of the basal ganglia are involved in the working memory. Working memory is a system that stores passing information in mind actively and it can also be manipulated. This system includes stored subsystems and manipulated visual images and as an administrative center coordinates subsystems. The system includes a visual representation of possible movements. Working memory needs to supervise especially in some parts of processes which involve in the completion of the activities related to the cognitive interferences [1]. Required cognitive processes to achieve this target include: Executive functions and attention from short-term memory, which cause temporary integration, processing, disposal and recovery information. These processes change in different diseases including Parkinson disease (PD) and they are sensitive to age and working memory is related to the cognitive evolution and also researches have shown that its capacity varies depending on age. Determination of the role of age, sex and education factors on memory is vitally important for designing neuro-cognitive test and these factors can determine the ability to assess the capacity of patient's working memory [2]. Comparing the results pattern of mentioned test in both sexes at different ages and various educations is associated with working memory abilities, and this comparison determines cognitive strengths and weaknesses of this cognitive field. Working memory rehabilitation is also associated with diverse cognitive approaches. In recent years there has been some basic evidences regarding the usefulness of different techniques for rehabilitation. There is also evidence of rehabilitation-induced plasticity [3].

The measures which have already been evaluated in this field include the systematic rehabilitation techniques such as the disappearance of symptoms and no error rehabilitation methods. Most studies have reported positive results in favor of systematic rehabilitation. However, issues related to the design and implementation of effective method is not clear and further studies are needed. Examining the evidence has been accompanied with clinical recommendations based on training and also asking physicians for inclusion of these methods to study the memory impairment in these patients. Implementation of effective methods of memory rehabilitation will facilitate linguistic-cognitive rehabilitation [11]. In addition to the improvement of the results, there are pragmatic benefits to support evidence-based rehabilitation practices. At the beginning, some criteria were created for the method and applying the evidence-based guidelines, some examples of these criteria were identifying critical factors for scientific clinical decision making [4]. Some priorities were developed for functional guidelines domains as well.

We obtained the protocol of rehabilitation model [2] after studying the evidence and chose Parkinson's patients in order to make the results of the research inclusive and also evaluate the evidences related to the people with performances derived from cognitive-linguistic disorders. Among these patients, memory impairment is typically a symptom of the disease. Memory disorders in these patients had no certain same conditions in comparison with the previous studies [4]. This study investigates a model of memory rehabilitation in patients with Parkinson's disease. The purpose of this study was to evaluate the patient's memory after memory rehabilitation with this model.

2. METHODS AND PATIENTS

2.1 Study Design

The present cross-sectional study was conducted on 120 patients with Parkinson and neuro-cognitive rehabilitation computerized test (NCAR) were used for assessment (before) and rehabilitation (after) in patients in 15 minutes. NCAR is a battery and CWMT is a part of this battery for assessment and rehabilitation of working memory. In this study, in addition to library of studies that were conducted in order to achieve theoretical background of the research, standardized task of NCAR were used for gathering information which is needed. NCAR battery is as follows: via the changing novel memory model [2]. This variable has six components and each component consists of six items. In the last study, in order to access validity and reliability of this task, it's used some scientists' comments in validity method of content and it confirmed by supervisor and consultant and for determining reliability of this task, they used Cronbach's Alpha Method. This method is used for computation inner harmony of calculators which calculate various features. Inclusion criteria were as follows: be in age range of 40 to 70 years, inhabitant of Tehran, right-handedness, Persian language speaker, lacking any history of neural and mental disease, surgery and medicine consumption. Exclusion criteria: not in age range of 40 to 70 years, not inhabitant of Tehran, left-handedness, not Persian language speaker, having any history of neural and mental disease, surgery and medicine consumption. In the current study, working memory was done through working memory computerized test of NCAR battery.

This test should done in a suitable place and performance conditions of the test must be observed psychologically. The purpose is that the examinee applies his maximum ability and has the best performance of working memory with a good speed. We applied this test for effective rehabilitation of working memory among these patients. The sample randomly consisted of 120 patients (according to the pilot study) of patients with PD (Response Rate: 100%) who visited the outpatient neuroscience department. The patients were in the age group of 40-70 years, of both sexes (60 male, 60 female). As the memory disorders in patients with PD had no certain consistent conditions similar to previous studies, it is really important to take into account other sources to study rehabilitation methods [5-9]. CWMT was based on three main variables: Age, sex, and education. We used this test for data collection.

2.2 Measures

CWMT*:* At first, some information about the implementation of test will be given to the individual and then he should click on page or press space or enter button on the keyboard to start the task. In this test there is an 8*8 matrix in every stage which only one box is on in each row and column of this matrix (its color is different). After 5 seconds, the matrix is rotated 90 degrees clockwise and the user should recognize that the new matrix is the same matrix as before or a new matrix is shown to him. In the case of being the same, he should press left shift button or press the left arrow on keyboard; and if it was not the same he should press right shift or right arrow button on the keyboard. If the answer was correct, the word correct will be displayed to him, and then he gets the chance to go to the next step. But if he does it wrong, incorrect word will be displayed to him. This process continues until the user press the Close button to exit the test or continue up to step 50, which is the last step in the test and its window will be automatically closed.

2.2.1 Variables of test

The number of correct responses (Correct Response), the number of error responses (Error Response), total time of correct responses based on Millisecond (Correct Time), total time of error responses based on Millisecond (Error Time), last step the user has done (Last Level), total time of task execution based on milliseconds (Time Rec).

2.2.2 Times in test

The time of showing the Ready Phrase at the beginning of the task: 2000 Millisecond*,* the time of showing each step: 5000 Millisecond, the time of showing Correct or Incorrect phrases: 2000 Millisecond, the time when the user has the opportunity to respond to the each stage: 10000 Millisecond, total time to do the task is considered 15 Minutes, the user then has the opportunity to implement the task up to end; otherwise it will be automatically closed after 15 minutes.

2.2.3 Results of test

After doing computerized test, data will be entered into $SPSS_{18}$ software and they will be analyzed through descriptive statistics and Pearson correlation coefficient tests and t-test. The assessment tasks are known as "digit capacity" or digit span when the numbers are used. Memory capacity is a common method for measuring the short-term memory. It is also some part of the cognitive abilities test.

2.3 Data Analysis

After completing demographic questionnaire and performing the working memory test by participants, Significance levels are bilaterally and statistical significance was set at 0.05. The statistical program used for analyzing the data was SPSS 18.0. Statistical analysis of this study was done through descriptive statistical tests, Pearson correlation coefficient and the t-test. Comparisons of frequency, mean, standard deviation, standard error of the mean variables to test working memory were done in patients with PD before and after rehabilitation. We evaluated t value with the variables working memory test in patients with Parkinson before and after rehabilitation.

3. RESULTS

Table 1 show that 50% of patients were female and 50% male, they were aged 40-70 years. Regarding educational level, 40% of patients were illiterate or primary school graduates, 17% high school graduates, 29% had diploma and 14% had bachelor. Finally, most patients (72.5%) were in the age group 60 to 70 years.

In particular, Table 2 shows the patients had done task and variables of task improved in correct response from 4.28 to 15.68, Error response decreased (4.17) in the after rehabilitation, also correct time increased and error time decreased. These data showed the patient improve in correct response but a long time and decreased error response with a short time. In this table, Last level (6.43) is low after rehabilitation and it confirmed patient fatigue. We know that PD introduces fatigue with their activity. Time record is important for storage of memory and it is short with rehabilitation (2.97). Finally memory span percent has been increased after rehabilitation (54.21).

In Table 3 show significant (0.000) for all of working memory test variables in patients with Parkinson before and after rehabilitation.

In Table 4 and Fig. 1 present significant ($0<0.05$) for all of working memory test variables with age in patients with Parkinson in after rehabilitation. According to the table, All variables testing working memory rehabilitation have significant P-value relationship in positive direction with age ($p<0.05$) after rehabilitation. There is also significant relationship between error time variable and age in negative direction ($p<0.05$) before rehabilitation.

According to Table 5 and Fig. 2, the variables of Correct Response , Correct Time, Time Record and Memory Span Percent of working memory test have significant P-value relationship in positive direction with sex in before and after rehabilitation ($p<0.05$).

According to Table 6 and Fig. 3, there is a relation between the variables of correct time, Error Time and time record with education in the negative direction after Rehabilitation and there is a relation between last level variable with education in the positive direction before rehabilitation ($p<0.05$).

Table 1. Demographics of Parkinson's patients

Variables		Number	Percent
Sex	Female	60	50 %
	Male	60	50 %
Education	Illiterate or primary school graduates	48	40%
	Under diploma	20	17%
	Diploma	35	29%
	Bachelor	17	14%
Age groups	40-50	12	10 %
	50-60	21	17.5%
	60-70	87	72.5 %

Table 2. Comparison of before and after rehabilitation

Variable	Group	Mean	Standard deviation	Standard error of the mean
Correct response	After rehabilitation	15.68	15.19	1.38
	Before rehabilitation	4.28	12.77	1.16
Error response	After rehabilitation	4.17	10.80	0.98
	Before rehabilitation	12.78	2.16	0.19
Correct time	After rehabilitation	1.85	0.92	0.81
	Before rehabilitation	4.01	9.76	0.43
Error time	After rehabilitation	2.97	2.20	0.20
	Before rehabilitation	5.94	2.06	0.93
Last level	After rehabilitation	6.43	20.40	1.86
	Before rehabilitation	27.12	20.40	1.86
Time record	After rehabilitation	2.97	2.20	0.20
	Before rehabilitation	9.83	4.02	1.64
Memory span percent	After rehabilitation	54.21	40.85	3.72
	Before rehabilitation	16.45	10.59	0.96

Table 3. Evaluation of the significance T value, the variables tested working memory in patients with Parkinson before and after rehabilitation

Variable	F	Sig	T	Df
Correct response	61.63	0.000	6.40	231.17
Error response	123.22	0.000	8.56	128.50
Correct time	24.32	0.000	4.65	237.86
Error time	24.89	0.000	4.12	141.67
Last level	862.06	0.000	10.99	124.02
Time record	352.14	0.000	9.74	130.91
Memory span percent	576.73	0.000	9.80	134.93

Table 4. The comparison of p-value and correlation of age with variables working memory test in patients with Parkinson before and after rehabilitation

Age	After rehabilitation	Before rehabilitation
Correct response	r=0.280	r=0.145
	p-value=0.002	p-value=0.114
Error response	r=0.447	r=0.135
	p-value=0.000	p-value= 0.142
Correct time	r=0.510	r= 0.093
	p-value=0.000	p-value=0.315
Error time	r=0.361	r= -0.316
	p-value=0.000	p-value= 0.000
Last level	r=0.448	r=0.096
	p-value= 0.000	p-value=0.297
Time record	r=0.463	r= -0.061
	p-value= 0.000	p-value=0.509
Memory span percent	r=0.447	r= -0.064
	p-value= 0.000	p-value=0.491

3.1 Future Scope

Today, according to the new therapy methods of cognitive rehabilitation we can significantly improve the patients' quality of life. Up to now several researchers from different countries paid attention to the working memory assessment in patients with PD and designing the computerized model for it. These assessments are non-invasive and inexpensive methods that will be conducted very easily in a private office. When there is slight memory impairment, computerized neuro-cognitive test of memory may be the only way to detect them. According to the experience gained during this study, we hope to apply the combined approach in the future studies. The future studies focus on assessing the validity of previous approaches. Accordingly, the results of future studies will be assessed focusing on the question that weather created rehabilitation method have been influenced by the same hypothetical promotion or not. The current study has also confirmed the rehabilitation through this model in patients with PD. The results will be examined in all of age groups in order to total trends rehabilitation. Extensive analysis about the interconnected immediate results showed some supportive evidence to use the systematic rehabilitation methods which were the same as the results of our study.

Table 5. The comparison of correlation, significance of sex with Variables working memory test in patients with Parkinson before and after rehabilitation

Sex	After rehabilitation	Before rehabilitation
Correct response	r=-0.036 p-value=0.001	r=0.299 p-value= 0.001
Error response	r=0.101 p-value= 0.271	r=0.079 p-value=0.394
Correct time	r=0.035 p-value=0.003	r=0.269 p-value=0.003
Error time	r=0.121 p-value=0.186	r=-0.011 p-value=0.905
Last level	r=0.049 p-value=0.095	r=0.120 p-value=0.190
Time record	r=0.075 p-value=0.003	r=0.268 p-value=0.003
Memory span percent	r=0.049 p-value=0.002	r=0.283 p-value=0.002

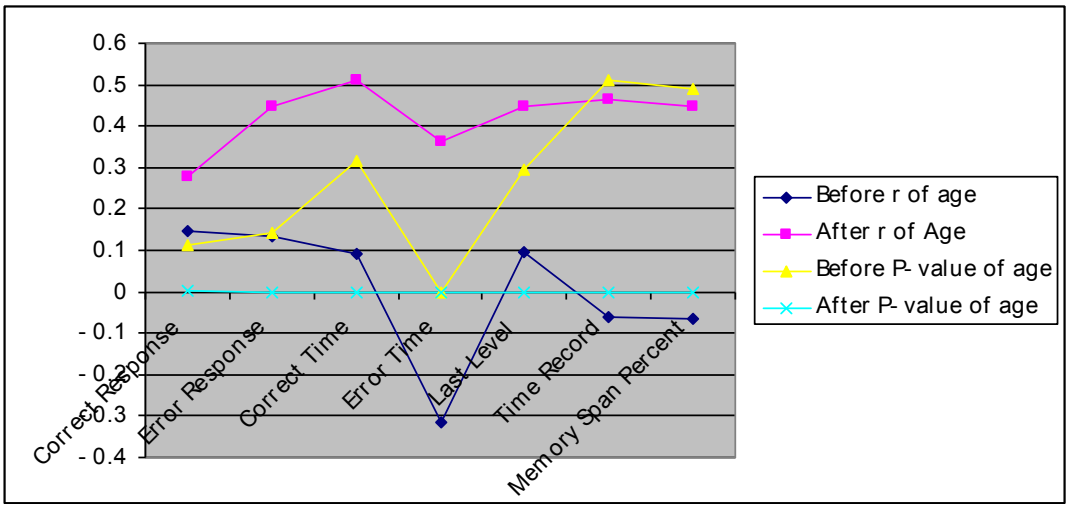

Fig. 1. The comparison of p-value and correlation of age with variables working memory test in patients with Parkinson before and after rehabilitation

Table 6. The comparison of correlation, significance, and p-value difference of education with Variables testing working memory in patients with Parkinson before and after rehabilitation

Education	After rehabilitation	Before rehabilitation
Correct response	r=0.018 p-value=0.842	r=0.091 p-value=0.325
Error response	r= -0.122 p-value=0.186	r=0.149 p-value=0.104
Correct time	r= -0.180 p-value=0.049	r= -0.019 p-value=0.836
Error time	r= -.160 p-value=0.080	r= -0.135 p-value=0.143
Last level	r= - 0.063 p-value=0.491	r=0.182 p-value=0.047
Time record	r= -0.184 p-value=0.045	r= -0.025 p-value=0.787
Memory span percent	r= -0.063 p-value=0.491	r= 0.104 p-value=0.258

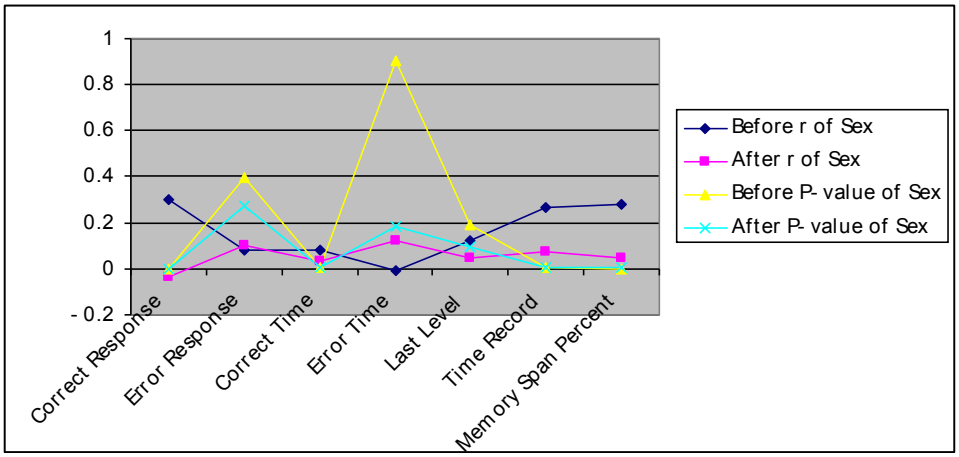

Fig. 2. The comparison of correlation, significance of sex with Variables working memory test in patients with Parkinson before and after rehabilitation

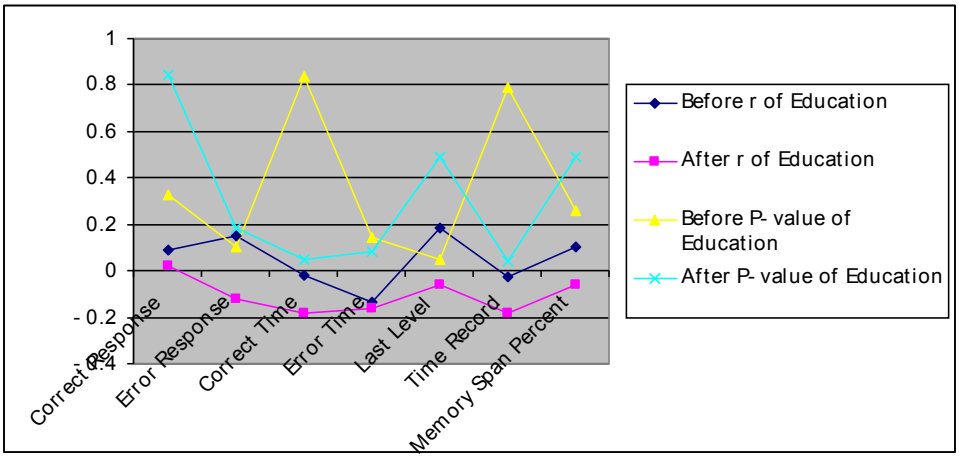

Fig. 3. The comparison of correlation, significance, and p-value difference of education with Variables testing working memory in patients with Parkinson before and after rehabilitation

4. DISCUSSION

The purpose of this study was to evaluate the patient's memory after memory rehabilitation with this model. In this study, mean of correct response and Last level variables were higher after rehabilitation , also Error response , Correct time , Time record and Error time were lower after rehabilitation, (Table 1). Result of study significantly show for all of working memory test variables in patients with Parkinson before and after rehabilitation (Table 3) and it showed significant for all of variables after rehabilitation (Table 4).

By raising our understanding about effective methods for memory assessment and their implementation, we can facilitate the memory rehabilitation. In addition to improve the rehabilitation outcomes, there are some pragmatic benefits to support evidence-based rehabilitation practices. In economic difficulties, cognitive rehabilitation is considered as a well designed guideline and the key for facilitating the efficient and sustainable positive outcomes in the patients with memory impairments. Up to now the role of factors like age, sex and education in working memory test has been evaluated based on different variables. Different researchers' models, such as baddeley include some different factors [2]. According to model factors, the role of factors like age, sex and education in working memory tests have been evaluated based on different variables [2]. Recent researches have determined the fact that the efficiency of working memory process depends on individual differences or diseases in working memory capacity.

As age grows the executive working memory establishes a stronger link with verbal working memory and also establishes fewer links with Visual-spatial functions. The phonetic short-term memory has the last link with executive working memory. The capacity of phonetic memory increases even without any coincidence increasing in executive working memory. This study assesses the working memory rehabilitation in patients with PD. Our aim in this study is assessing of the computerized model of working memory rehabilitation based on three main variables of age, se x and education in these patients. These tests can be also used to identify problems related to medical conditions that can affect memory and thinking, such as Parkinson's disease, diabetes, high blood pressure, brain hit, Huntington's, fibromyalgia, stroke, kidney disease, cognitive decline after surgery, alcoholism, etc. CWMT helps to distinguish memory disorders and is also used for the managing more effective treatment including medical and non-medical cure. Test results from these tests can be applied in order to schedule the treatments using strengths points to compensate for weaknesses. The results of these tests can lead to identify the existing memory problems and also detect useful strategies. The cognitive-linguistic rehabilitation will be facilitated by raising our understanding about effective methods for memory rehabilitation and implementation of them [10]. The current model in economic difficulties, cognitive rehabilitation is considered as a well designed guideline and the key for facilitating the efficient and sustainable positive outcomes [11,12]. Last studies such as our method indicate to optimal rehabilitation by using no error rehabilitation methods, the method of removing clues, interval rehabilitation, or systemic rehabilitation package will be happen. Favorite results have been obtained in all demographic groups which the strongest result, as it was predictable, belonged to dementia population and these results may be slightly different from the results in patients with Parkinson's disease. In another studies showed negative results [13]. In our study subjective group were not from this age group. The other researchers worked on dementia, they showed positive results [13], while some of studies suggested sufficient results in rehabilitation [14]. The researchers achieved sufficient results in their studies and reported immediate desirable results [15]. Also they reported the generalization of remembering faces – names to a real environment in patients with memory deficit and using memory strategies in new situations for the participants [17]. The Distribution in this study will be possible on condition that we enter more volume in the study because the results before and after rehabilitation were desirable (Tables 3 and 4).

The maintenance results were obtained when the re-evaluation of goals occurred over a day after the train stopped. Researchers called this time as "maintenance". Maintenance controls in the last studies were reported. They reported about the unfinished maintenance or 100% of the rehabilitation goals from a few days to nine months after the intervention [16,17]. The positive effects of treatment remained until six months after the intervention. The amount of prescribed treatment refers to the frequency and

duration of treatment sessions, both in terms of sessions' length and the general time in which patients have been cured. Frequency of treatment ranged from single session to every day session; the number of hours of treatment differed as well. Some sessions lasted for 30 minutes and the other 2 hours. Some medical practices lasted a week and some took several months. Frequency of treatment varied in different situations from at least one treatment session to 16 sessions. The total duration of treatment ranged from one to four weeks.

5. CONCLUSION

Some of studies reached to incomplete or complete distribution goals of rehabilitation [16]. The researchers pointed out that the assistant rehabilitation group has remarkably progressed in the review of selective distribution. The overall results of maintenance control reported positive [18]. Half of the studies have focused on the therapeutic situation. These studies described a range of opportunities such as: experimental or clinical situations, workplace and home remedy through the phone. Some of studies reported about treatment providers including examiner and family members as well as computerized stimuli which were mentioned in resent studies.

CONSENT

All authors declare that 'written informed consent was obtained from the patient (or other approved parties) for publication of this case report and accompanying images.

ETHICAL APPROVAL

All authors hereby declare that all experiments have been examined and approved by the appropriate ethics committee and have therefore been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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