

Original Research Article

A Comparative Study of Iranian Smell Identification Test (Iran-SIT) and Single-photon Emission Computed Tomography (SPECT) Results in Discrimination of Anosmia and Malingering in Forensic Cases

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Abstract: Purpose: Olfactory dysfunction is a common complaint following head trauma. Few subjective and objective tests had been proposed for purposes of litigation. Currently, the two most common methodologies for separating malingerers from genuine anosmics are single-photon emission computed tomography (SPECT) and smell identification tests as objective and subjective tests, respectively. The objective of the present study was to compare the efficacy of the SPECT and Iranian Smell Identification Test (Iran-SIT) in discrimination of anosmia and malingering in forensic cases. Method: All of the 16 subjects that fulfilled the requirements completely, underwent both SPECT imaging and Iran-SIT assessment. Results: The sensitivity of SPECT in diagnosing malingering and anosmia was estimated to be 66.6% and 87.5%, respectively. That of Iran-SIT was estimated to be 90% and 75%, respectively. In addition, the sensitivity and specificity of Iran-SIT in diagnosing hyposmia were 100%. Conclusion: Because of the higher sensitivity of Iran-SIT in diagnosing anosmia and higher specificity in diagnosing malingering, it is recommended for directly ruling out the suspicious cases.

Keywords: Olfactory dysfunction; Forensic medicine; Anosmia; Malingering; SPECT; Iran-SIT

1. Introduction

Smell has been known as one of the oldest senses of human which plays a major role in the feeding behavior, protecting against environmental hazards and spoiled food, occupational tools as well as social communication. Olfactory disorders usually occur as the result of head trauma, medical intervention, sinus or nasal disease, neurodegenerative disease, aging and exposure to a number of environmental pollutants^[1-5].

Despite the fact that daily life impairment seems to be a major determinant of olfactory disorders, clinical otolaryngologists have limited means to diagnose these problems properly^[6]. In recent years, various methods have been developed to measure olfactory function in the clinical setting including Psychophysical Tests (e.g. Odor Identification, Odor Detection, Odor Discrimination/Memory), Electrophysiological Tests (e.g. Electro-olfactogram, Event-Related Potential), Psychophysiological Tests (e.g. Cardiovascular Changes, Inhalation Changes), Structural & Functional Im-

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aging (e.g. Magnetic Resonance Imaging (MRI) & functional MRI (fMRI), Positron Emission Tomography (PET), Single Photon Emission Computed Tomography (SPECT), and Diffusion Weighted Imaging (DWI))^[7-9]. These sensory tests can be classified as “subjective” or “objective” with their own advantages and disadvantages.

Malingering has been defined as “the intentional production of false or grossly exaggerated physical or psychological symptoms motivated by an external incentive such as avoiding military duty, avoiding work, obtaining financial compensation, evading criminal prosecution, or obtaining drugs” regarding the American Psychiatric Association (2000)^[10]. Previous studies showed that approximately 14% of chemosensory patients have been malingering the loss of olfaction ability; this might be even higher for patients involved in compensation litigation^[11,12]. The feigning of olfactory loss has always been considered as a challenge for practitioners at smell clinics, especially when the result might worth many thousands of dollars to the patient. For purpose of litigation, the olfactory measuring tools seem to be still rather limited. Currently, medical history and statistical inference are among the most common methodologies of identifying olfactory loss malingerers^[13,14]. As mentioned earlier, there are some objective and subjective analyses to assess the functionality of olfactory system but each of them suffers from some limitations. Psychophysical olfactory tests mostly provide a more sensitive assessment than do electrophysiological measures as well as functional imaging and provide many advantages, including lower costs, ease of administration and rapid results. Despite the presumption that “subjective” tests are easier to malingering than “objective” tests, many so-called “objective” olfactory tests are not immune to malingering. Reliable objective measurements require considerable subject cooperation and also there are still technical issues which can lead to difficulties with interpretation in borderline patients. On the other hand, some objective tests suffer from lower sensitivity, lower resolution, lower observational time window and also higher costs^[7,15,16].

The following experiment employs a subjective as well as an objective technique to make a comparison between their efficacies in discriminating malingerers from real anosmic cases.

2. Iran smell Identification test (Iran-SIT)

The University of Pennsylvania Smell Identification Test (UPSIT), a well-known subjective tool for diagnosing olfactory disorders, applies a forced-choice paradigm. Individuals with significantly lower levels of performance are determined as malingerers^[6]. Iran Smell Identification Test (Iran-SIT)^[17], a standardized 40-item smell identification test is a modified version of UPSIT to assess the olfactory function of Iranian population considering cultural adaption. It has the adequacy to classify olfactory disorders into four levels: normosmia (the normal olfactory function), mild microsmia (mildly decreased olfactory function), severe microsmia (severely decreased olfactory function) and anosmia (loss of olfactory function).

3. Brain single photon emission tomography (SPECT)

Brain SPECT is a noninvasive technique for functional neuroimaging of physiologic and physiopathologic events in the human brain. It is an objective tool to define the pathologic status of a patient when neurologic symptoms cannot be explained by structural neuroimaging. The brain SPECT could be a valuable tool but the high sensitivity in detecting functional impairment is counterbalanced by poor specificity; it means that the same SPECT pattern may be referred to different pathologies^[18].

Spatial resolution is the main concern in brain imaging of small size cerebral structures via SPECT. Although high doses of radiopharmaceuticals can increase detection sensitivity and spatial resolution, the dose is limited by safety issues. Sensitivity to the environmental conditions like loud noise, inappropriate light, and existence of any smell in the room is another problem which might disturb results of the rest-stress analysis.

Other disadvantages that have decreased the clinical popularity of brain SPECT are high costs, unreliable supply of radiopharmaceuticals like Tc-99m, longer acquisition time which in turn increases the risk of patient motion and also dependency to patient preparation, cooperation and consciousness^[15,17,19,20].

4. Materials and methods

4.1 Subjects

Twenty-two post-traumatic subjects (4 women and 18 men) between 13 and 52 years (33.75 ± 11.08) were recruited from the cases referred to the General Office of Legal Medicine at Eastern Azerbaijan Province branch with the complaint of anosmia. A total of 6 out of 22 individuals were excluded due to various exclusion criteria (e.g., four cases refused to take SPECT imaging, one refused to take Iran-SIT and one was an inappropriate case). Eventually, 16 individuals entered the experiment.

4.2 Procedure

All of the 16 subjects that fulfilled the requirements completely, underwent both SPECT imaging and Iran-SIT assessment. Brain perfusion SPECT was obtained following IV administration of 30 mCi ^{99m}Tc ECD in two different phases, rest and after stimulation with vanilla. SPECT imaging was then obtained 60 minutes after injection for each phase. Briefly, olfactory function was assessed in all patients with a 40-item smell identification test named Iran-SIT in four alternative forced-choice paradigms which were designed particularly for forensic cases. Scoring in Iran-SIT olfactory assessment was as following: The number of items correctly identified ranges from 0 to 40. Scores under 5 were assumed as probable malingering, scores between 6 and 7 were to be re-tested, scores between 8-14 were assumed as anosmia and those more than 15 were assumed as hyposmia. All of the patients had received brain SPECT imaging prior to Iran-SIT.

4.3 Statistical analysis

Statistical analysis was carried out using SPSS (v22). Diagnostic accuracy was defined as the sensitivity, specificity, positive and negative predictive values (PPV and NPV) and also positive and negative likelihood ratios (LR+ and LR-). Finally, we used Kappa test and ROC curve to compare the consistency of the two examinations. P values of less than 0.05 were considered statistically significant.

5. Results

5.1 Descriptive analyses

The 16 patients aged between 13 and 52 (33.75 ± 11.08); the majority (14/16) were male. In the Iran-SIT test, 7 cases were diagnosed as anosmic, 2 as hyposmic and 4 as malingering consistent with SPECT. This result was equal to 81.25% consistency which is a satisfying percentage. 18.75% of the Iran-SIT results were inconsistent with those of SPECT but we were not sure which one was accurate, because SPECT had no standardized criteria for olfactory disorders and had some disadvantages like lower specificity; on the other hand, the sample size ($N = 16$) was too small to draw a decisive conclusion.

5.2 Accuracy of Iran-SIT in clinically diagnosed anosmic and malingering patients

In the Iran-SIT test, 5 subjects were diagnosed as malingerers, 4 of which had normal perfusion reported by SPECT. 11 of the 16 subjects had olfactory disorder by Iran-SIT but 2 of them were diagnosed malingering by SPECT. Taking SPECT results as the gold standard, the sensitivity and specificity of Iran-SIT were calculated as follows: the sensitivity in diagnosing malingering and anosmia was estimated to be 66.6% ($4 / (4+2)$) and 87.5% ($7 / (7+1)$), respectively. The specificity was estimated to be 90% ($9 / (9+1)$) and 75% ($6 / (6+2)$), respectively. The sensitivity and specificity in diagnosing hyposmia were 100%. Flowchart of test results for each subgroup was demonstrated in **Figure 1** and **2**.

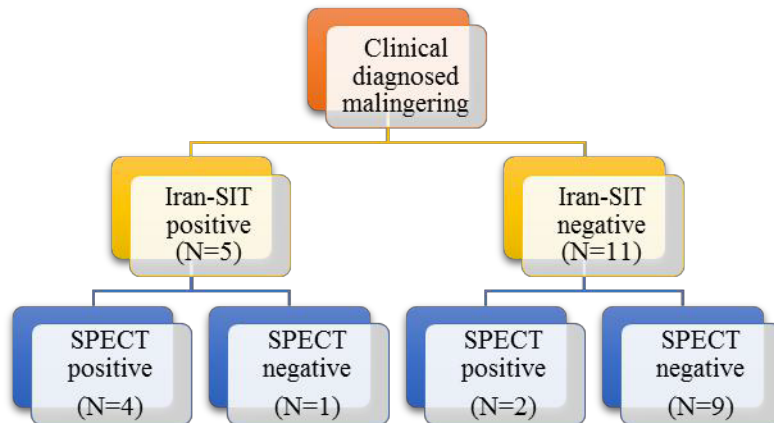


Figure 1. The flowchart of categorizing malingering subjects by means of Iran-SIT and SPECT.

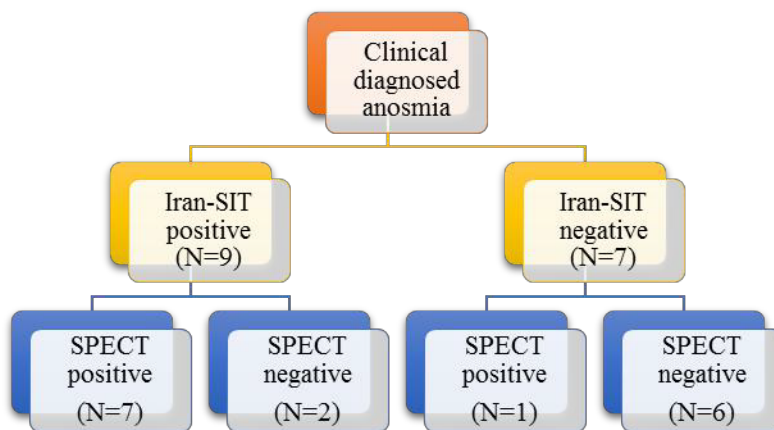
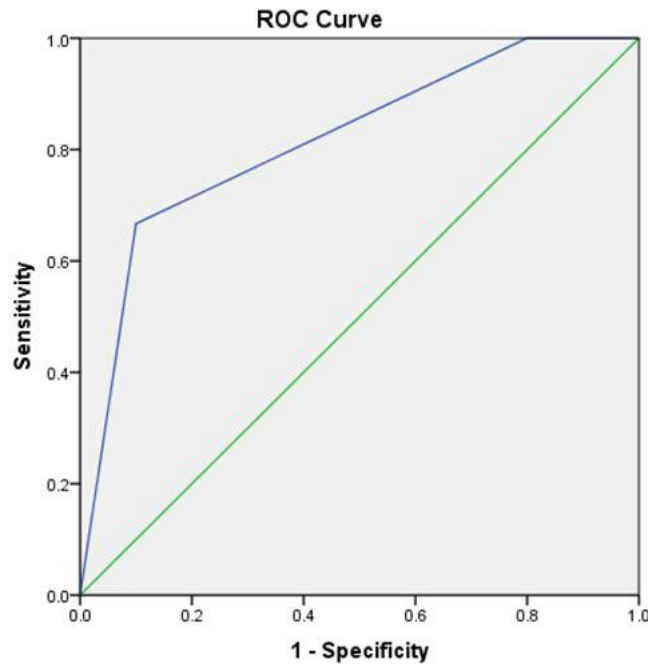


Figure 2. The flowchart of categorizing anosmic subjects by means of Iran-SIT and SPECT.

The Receiving Operator Characteristics (ROC) curve plots the true positive rate (sensitivity) as a function of the false positive rate (1-specificity). Accuracy is measured according to the area under the ROC curve (AUC). An area of 1 represents a perfect test, while an area of 0.5 represents a worthless test. ROC analysis was also used in order to assess the accuracy of Iran-SIT, as the screen test, in distinguishing malingerers from real anosmic subjects (**Figure 3**). The area under the curve is listed in **Table 1**. The traditional academic point system is a rough estimation for categorizing the accuracy of a diagnostic test:

0.90-1.00	Excellent (A)
0.80-0.90	Good (B)
0.70-0.80	Fair (C)
0.60-0.70	Poor (D)
0.50-0.60	Fail (F)



AUC=0.817 95% CI (0.590 -1.000)

Figure 3. ROC analysis showed the accuracy of Iran-SIT, as the screen test, in distinguishing malingerers from real anosmic subjects. Diagonal segments were produced by ties.

Table 1. Area under the curve. Test result variable(s): Iran-SIT

Area	Std. Error ^a	Asymptotic Sig. ^b	Asymptotic 95% Confidence Interval	
			Lower Bound	Upper Bound
0.817	0.115	0.039	0.590	1.000
The test result variable(s): Iran-SIT has at least one tie between the positive actual state group and the negative actual state group. Statistics may be biased.				
a. Under the nonparametric assumption				
b. Null hypothesis: true area = 0.5				

The ideal limit (lower band 95% CI) was more than 0.5 which confirmed the acceptability of the test. According to the traditional academic point system, the accuracy of Iran-SIT in discrimination of malingerers from real anosmic subjects falls into the B class, which represents a good accuracy.

The Youden's index (J), a common summary measurement of the ROC curve, is the difference between the true positive rate and the false positive rate: $J = \text{Sensitivity} + \text{Specificity} - 1 = 0.56$

5.3 Predictive value of Iran-SIT for the results of SPECT

To estimate the predictive values of Iran-SIT for discriminating anosmia and malingering, all 16 patients were included in the analysis. The positive predictive value (PPV) of Iran-SIT for malingering and anosmia was 80% (4/5) and 77.7% (7/9), respectively. The negative predictive value (NPV) was 81.8% (9/11) and 85.7% (6/7), respectively.

Positive and negative likelihood ratios (LR+, LR-) are used for assessing the value of performing a diagnostic test using the sensitivity and specificity of the test to determine the probability that a condition exists:

$$LR+ = \frac{\text{Sensitivity}}{1-\text{Specificity}} \quad LR- = \frac{1-\text{Sensitivity}}{\text{Specificity}}$$

LR+ and LR- for diagnosing anosmia by Iran-SIT were 3.5 and 0.17, and for diagnosing malingering were 6.67 and 0.37, respectively. McGee *et al.* introduced a simple method of applying LR^s[21]. According to his table of estimation, which is independent of pretest probability, a finding with an LR of 3.5 and 6.67 increases the probability of dis-

ease by about 25% and 40%, respectively. Finding with an LR of 0.17 and 0.37 decreases probability of disease by about 45% and 25%.

In summary, in 13/16 subjects (81.25%), the results of Iran-SIT were consistent with the results of the SPECT imaging (Kappa test, Kappa coefficient=0.680, $p<0.05$). Cohen's κ was run to determine if there was an agreement between the results of Iran-SIT and SPECT in discriminating malingering and anosmia for legal medicine applications. Cohen suggested the Kappa coefficients in the range of 0.61- 0.80 to be interpreted as substantial agreement^[22].

6. Discussion

Dissimilar to auditory and visual senses, olfaction has always been undervalued. A complete assessment of olfactory disorder requires a standardized olfactory test. Development of valid and reliable olfactory tests, as well as increased awareness of olfactory disorders among physicians will significantly decrease the number of misunderstood malingering and real anosmic cases^[23]. Many objective and subjective tests have been developed for diagnosing olfactory disorders but only a few are for clinical assessment of olfactory performance as a routine. The reason could be high costs, low reliability, safety issues with radiopharmaceuticals, patient-dependent problems, and long time needed for administration and cross-cultural differences.

Malingering has always been considered as a big problem in legal medicine because the result might worth many thousands of dollars to the patient; therefore, ability to rule out the malingerers with an inexpensive and convenient but hard to cheat smell identification test will certainly benefit forensic specialists very much. In the present study, we try to investigate whether the 40-item Iran-SIT holds the qualification as a substitute for brain SPECT to detect malingering and anosmia in forensic cases.

Cohen's κ (Kappa coefficient=0.680, $p<0.05$) demonstrated a substantial agreement between the results of Iran-SIT and SPECT in discriminating malingering and anosmia for legal medicine applications. The AUC (area under the ROC curve) was 0.817 CI-95% (0.590-1.000) and the ideal limit (lower band CI95%) was more than 0.5, which confirmed the acceptability of the test. According to the traditional academic point system, the accuracy of Iran-SIT in discriminating malingerers from real anosmic subjects falls into the B class, which represents a good accuracy.

Atighechi and colleagues compared the application of brain MRI and SPECT in diagnosing olfactory dysfunction after head trauma. They demonstrated that the sensitivity and specificity of brain SPECT in diagnosing anosmia were 85.7% and 87.7%, respectively, in comparison to 82.1% sensitivity and 87.7% specificity by MRI^[24]. Our current investigation revealed that due to higher sensitivity (87.5%) in detecting anosmia, higher specificity (90%) in diagnosing malingering and also approximate high positive and negative predictive values, Iran-SIT can be a very valuable tool for discriminating malingering from real anosmia in Iranian population instead of brain SPECT, which had higher cost and lower specificity (**Figure 4** and **Table 2**). The PPV in diagnosing anosmia and malingering was 77.78% and 80.00%, respectively. The sample size might be too small (N=16) and more subjects are necessary in the future to produce more representative results of the population.

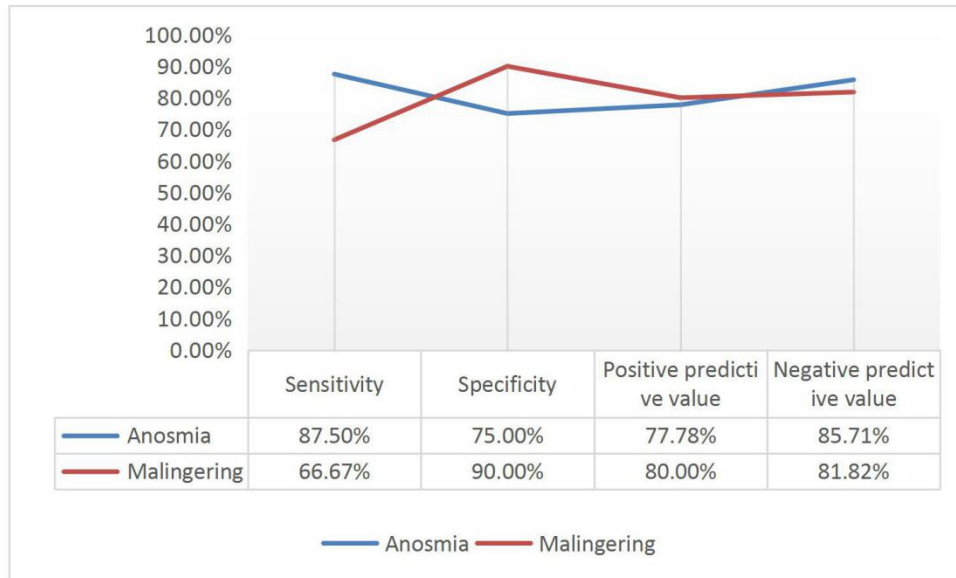


Figure 4. The accuracy of Iran-SIT in clinically diagnosed anosmic and malingering subjects.

Table 2. Summary of statistics of Iran-SIT in diagnosing anosmia and malingering

	Iran-SIT	
	Anosmia	Malingering
True Positive	7	4
False Positive	2	1
False Negative	1	2
True Negative	6	9
Sensitivity	87.5%	66.67%
Specificity	75.00%	90.00%
Positive likelihood ratio	3.5	6.67
Negative likelihood ratio	0.17	0.37
Positive predictive value	77.78%	80.00%
Negative predictive value	85.71%	81.82%

6. Conclusion

It is impossible to underestimate the importance of smell sense in quality of life. Despite its importance, there are still few valid methods for assessment of olfactory performance. Iran-SIT is a non-invasive, low cost, sensitive, rapid and convenient procedure recommended to be used as a clinical test for classifying olfactory disorders as well as distinguishing malingerers from real anosmia in legal medicine. The higher consistency of Iran-SIT as a subjective test (~81.25%) with brain SPECT as an objective test suggests that it can be a better alternative to brain SPECT with lower cost, ease of application, patient comfort, and higher safety.

Because of the higher diagnostic sensitivity of Iran-SIT in diagnosing anosmia and the higher specificity in diagnosing malingering, it is recommended for directly ruling out the suspicious cases. If 40-item Iran-SIT is used in accompany to other medical documents, it would have even higher accuracy for ruling in the suspicious cases; therefore it is reasonable to replace an expensive test like brain SPECT with a lower cost and convenient test like Iran-SIT.

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