Clinical Comparison of Temporomandibular Joint Sound Auscultation and Emission Imaging Studies

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Single photon–emission computerized tomography scintigraphy was used to examine 250 patients who previously had temporomandibular joint sounds auscultated and recorded with a Doppler machine. Patients were divided into four groups based on the presence of joint sounds: no sound, reciprocal clicks, reciprocal clicks with crepitus, and crepitus. Statistically significant differences between the groups and the single photon–emission computerized tomography scintigraphy results were determined. There was no correlation between these results and the no sound and crepitus groups, but significant correlation was established between positive results and crepitant joints with reciprocal clicks and noncrepitant clicking joints.

J OROFACIAL PAIN 1994;8:55–60.

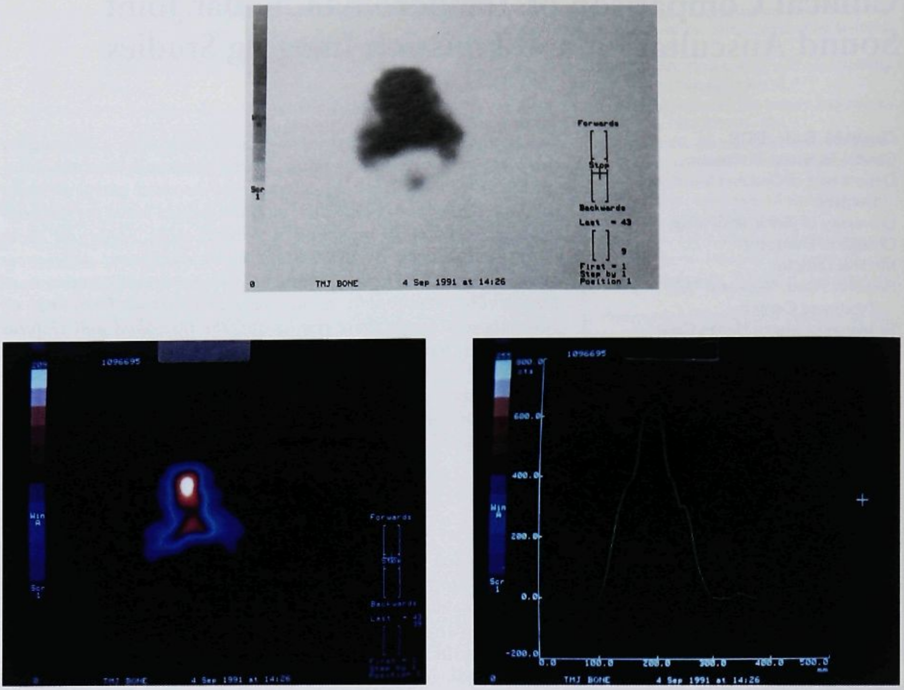
Evaluation of temporomandibular joint (TMJ) pain associated with intracapsular dysfunction has perplexed clinicians for many years. Use of various imaging techniques as indirect evidence of inflammatory or degenerative changes in the TMJ has not shown specificity in correlating clinical symptoms with imaging results. Radiographic imaging detects changes in bone only after 50% demineralization has occurred.[1,2] However, single photon–emission computerized tomography (SPECT) bone scans will detect a 10% increase of osteoblastic and osteoclastic cellular activity.[3–7] Sherman et al[8] concluded that scintigraphy is valuable for the confirmation of the lack of subclinical inflammatory arthritis. Collier's work indicated a 94% sensitivity to increase cellular activity,[9] and Kircos[10] indicated a 93% sensitivity within the population he observed. Furthermore, Kircos stated that emission patterns are specific, and this appearance may aid in the differentiation of active and arrested disease.[10–12]

Studies have also examined the diagnostic capacity of measuring and recording joint sounds.[13–18] Correlation of various pathologic conditions of the TMJ with these audible joint sounds has been attempted. Joint sounds have been auscultated with the aid of a stethoscope, sonogram, and Doppler magnification.[18–20] Doppler auscultation is the ultrasonic amplification of functional sounds.[19–21]

This retrospective study examines the relationship between SPECT results and various joint sounds.

Materials and Methods

The patient population was drawn from a multiracial, industrial urban area. The patients were evaluated at an outpatient interdisciplinary temporomandibular treatment center located in a medical-

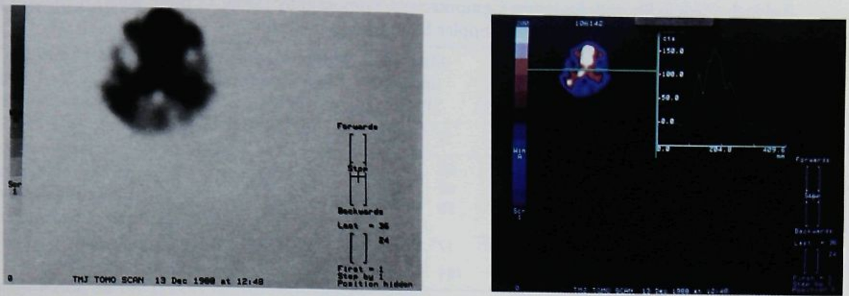


Figs 1a to 1c Views showing no significant radionuclide uptake.

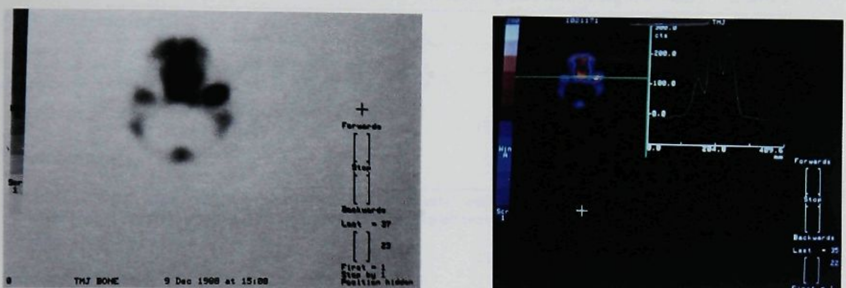
surgical hospital. Single photon–emission computerized tomography scintigraphy examinations were obtained on 258 patients who had a chief complaint of preauricular pain. Intracapsular dysfunction and inflammation were considered the primary etiologic factors in preauricular pain for these patients. All patients received an intravenous dose of 22 mCi TC 99m MPD (technetium-99m medronate sodium) 2 hours prior to the imaging study. The imagining was performed with a SPECT scintillation camera. Static planar images were obtained of the anterior, posterior, right, and left lateral skull views.

On the SPECT system, 64 planar images were obtained in a 360-degree orbital rotation for 20 seconds per view in a 64 × 64 matrix. The orbit was set for either an elliptical or circular tomogram pattern depending on the patient's physical size. The pattern selected was the one that utilized the least overall distance between the patient to the camera. Transaxial, sagittal, and coronal images were reconstructed from the planar images. This was done using the Nowak reconstruction method.[22-23] Once the transaxial, sagittal, and coronal images had been generated, the image number of the transaxial slice in which the TMJs first appear was determined. The following two slices were used to generate a curve that resulted in a quantitative analysis of the metabolic activity over the TMJs and the intervening bony structures (Figs 1 to 3).

Prior to imaging, all patients' TMJs were examined with Doppler sound magnification, which uses ultrasonic waves to magnify and reflect frictional joint sounds.[20] A Huntleigh mini-Doppler D500 (Huntleigh Medical, Cardiff, United Kingdom) with an 8-mm transducer head was used. The chart recorder (Huntleigh Dopcord, USA) was set at a chart speed of 25 mm/sec, and the gain was set at 20 mV/mm. Placement of the ultrasonic transducer head was accomplished as described by Piper.[21] Rotational and translatory movements were recorded.



Figs 2a and 2b Views showing moderate radionuclide uptake and increased osteoblastic and osteoclastic cellular activity.



Figs 3a and 3b Views showing significant radionuclide uptake and associated cellular activity.

Results

All 258 patients were divided into four groups according to the functional sounds obtained and recorded with Doppler sound magnification. The four groups were: *(1)* no sounds, *(2)* reciprocal clicks only, *(3)* reciprocal click with associated crepitus, and *(4)* crepitus only. Using this hierarchical classification system, 38 patients (15%) were found to have no joint sounds (group 1), 109 patients (42%) had reciprocal clicks (group 2), 89 patients (31%) had reciprocal click with crepitus (group 3), and 30 patients (12%) had crepitus only (group 4).

Initial groupings of SPECT results were divided into minimum, moderate, and significant radionuclide uptake where any amount of radionuclide uptake was considered a positive result.[8] Negative SPECT examinations (no uptake) were recorded for 50 of the 258 patients (20%). Of the remaining 208 patients who had positive SPECT results, 24 (12%) exhibited no joint sounds, 93 (45%) exhibited reciprocal clicks only, 70 (33%) exhibited reciprocal clicks with associated crepitus, and 21 (10%) exhibited crepitus only. The chi-square analysis of this data indicated a significant relationship between joint sounds and radionuclide uptake (χ^2 = 17.31, $P < .04$) (Table 1). The data indicated a positive relationship between two variables; as functional sound severity increased so did the amount of radionuclide uptake.

After determining that a relationship existed between joint sound and radionuclide uptake, a one-way analysis of variance (ANOVA) was performed to determine if there was a significant difference in radionuclide uptake in the four joint sound groups. The ANOVA demonstrated a significant difference between the various sound groups and SPECT results (F = 4.13, $P <= .007$).

A Tukey Studentization Range post hoc test was performed to identify which groups were significantly different. The mean determined by the post hoc test represents where the statistical significance of the SPECT results exists when compared to the

Table 1 Single Photon–Emission Computerized Tomography (SPECT) Bone Scan Results by Joint Auscultation with Doppler Sound Magnification

	Negative SPECT		Minimal uptake SPECT		Moderate uptake SPECT		Significant uptake SPECT	
	N	%	N	%	N	%	N	%
No Joint Sound	14	28.0	23	12.7	1	4.5	–	–
Reciprocal Click Only	16	32.0	82	45.3	9	40.9	2	40.0
Reciprocal Click with Any Crepitation	11	22.0	59	32.6	8	36.4	3	60.0
Any Crepitation Only	9	18.0	17	9.4	4	18.2	–	–
Total	50		181		22		5	

$\chi^2 = 17.31$, $P \leq = .04$.

Table 2 Tukey's Studentized Range Test for Variable: SPECT

Grouping		Mean	N	Sound
	A	1.037037	81	3***
	A			
	A	0.972477	109	2**
	A			
B	A	0.833333	30	4****
B				
B	A	0.657895	38	1*

Means with the same letter are not significantly different. *–None, **–minimum, ***–moderate, ****–significant. SPECT results: $\alpha = .05$, DF = 254, MSE = 0.3406, Studentized Range = 3.65733, LSD = 0.304055, harmonic mean of cell sizes = 49.2798.

joint sound groups. No significant difference was determined when comparing SPECT results with joint sound groups 1 (no sound) and 4 (significant). A significant difference was determined to exist with SPECT results and groups 2 (minimal) and 3 (moderate) (Table 2).

Discussion

This paper reviews the correlation between joint sounds and SPECT results. Single photon–emission computerized tomography scintigraphy represents a measurement of active physiologic change at the cellular level; joint sounds represent biomechanical changes in a joint that can be correlated to pathologic changes in the joint. Positive SPECT results indicate an elevation of osteoclastic and osteoblastic cellular activity by increased radionuclide uptake. This increased activity occurs either during inflammation or active degenerative change. A negative SPECT scan can be interpreted as noninflammatory, nondegenerative remodeling of the joint as a response to normal or abnormal function.

According to Wilkes,[24-26] various degrees of staging of internal derangement exist. These progressive stages are based on clinical, radiologic, and surgical findings. Cay et al[17] demonstrated the relationships of joint sounds and joint movement by arthophonometric studies.

Significant correlation was established between positive SPECT results and crepitant joints with reciprocal clicks and noncrepitant clicking joints. Nonclicking crepitant joints did not demonstrate any correlation with SPECT results. The post hoc analysis seems to support the hypothesis that osteoarthritic joints burn out.[27-30]

The degree of adaptability of a joint would reflect the amount of ongoing physiologic change. The present study indicates that there is not a correlation between crepitus and physiologic activity. Joint sounds in themselves are not diagnostic for determining the physiologic state of a joint. Perhaps a combination of magnetic resonance imaging, clinical examination, and SPECT scan will establish gold standards. This combination of studies may allow differentiation between remolding phenomenon and actual pathologic process.

Conclusion

The need to determine physiologic changes within the TMJ is essential to determine the activity of various inflammatory and active degenerative stagings. The use of SPECT analysis to compliment other imaging techniques of the TMJ presents interesting possibilities. The establishment of diagnostic algorithms using joint sound analysis, various imaging techniques, and SPECT analysis may improve the specificity of diagnostic conclusion. The authors believe that SPECT analysis is a useful tool based on the results of this retrospective study and that controlled studies need to be performed to determine the validity of this study.

Acknowledgment

The authors wish to thank the following individuals for their contributions: Louis Mercuri, DDS, MS and Sandra Barnett.

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Resumen

Comparación clínica de estudios de auscultación de sonidos y de emisión de imágenes en la articulación temporomandibular.

Se utilizó la gammagrafía tomográfica computarizada con emisión de fotón simple, para examinar a 250 pacientes a quienes previamente se les había auscultado los sonidos de la articulación temporomandibular y asimismo grabados con una máquina Doppler. Los pacientes fueron divididos en cuatro grupos basados en los sonidos de la articulación: sin sonidos, sonidos de clic recíprocos, sonidos de crepitación y de clic recíprocos, y sonidos de crepitación. Se determinó que existían diferencias estadísticamente significativas entre los grupos y los resultados de la gammagrafía tomográfica computarizada con emisión de fotón simple. No se pudo establecer una correlación entre estos resultados y el grupo libre de sonidos como tampoco en el grupo que presentaba sonidos de crepitación, pero sí se estableció una correlación significativa entre los resultados positivos y las articulaciones crepitantes con sonidos de clic recíprocos y las articulaciones no crepitantes con sonidos de clic.

Zusammenfassung

Klinischer Vergleich zwischen Auskultation von Kiefergelenksgeräuschen und SPECT - Studien.

"Single photon-emission" - Computertomographie (SPECT) wurde verwendet zur Untersuchung von 250 Patienten, die zuvor in auskultatorischer- und Doppler-Untersuchung Kiefergelenkgeräusche gezeigt hatten. Die Patienten wurden basierend auf ihren jeweiligen Kiefergelenksgeräuschen in vier Gruppen eingeteilt keine Geräusche, reziprokes Knacken, reziprokes Knacken mit Reiben, Reiben. Statistisch signifikante Korrelationen zwischen diesen Gruppen und den SPECT-Resultaten wurden ermittelt. Zwischen den SPECT-Resultaten und der Gruppe ohne Geräusche bzw. der Gruppe mit Reiben konnte keine Korrelation gefunden werden, aber es bestand eine signifikante Korrelation zwischen positiven SPECT-Resultaten und Gelenken mit reziprokem Knacken mit bzw. ohne Reiben.