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# A comparison of magnetic resonance imaging and cone beam computerized tomography in the evaluation of temporomandibular joint changes in rheumatoid arthritis patients

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Rheumatoid Arthritis, case-control study, CBCT, MRI, degenerative changes.

**ABSTRACT**

This study aimed to determine the features of temporomandibular joint (TMJ) involvement in rheumatoid arthritis (RA) patients and comparing the diagnostic efficacy of cone-beam computerized tomography (CBCT) to magnetic resonance imaging (MRI) in identifying changes of TMJs. This case-control study was performed on 40 RA patients with ten healthy adults (control cases). CBCT and MRI examination were done for participants. Independent and paired t-tests and correlation coefficient tests were used for data analysis by SPSS program. The frequency of TMJ involvement using CBCT and MRI techniques were 82.5% and 87.5% in RA patients and were 50% and 30% in control cases. The commonest change in CBCT of RA patients was condylar head erosion (67.5%), and the less common change was articular eminence erosion (7.5%). The commonest changes in MRI of RA patients were an osseous change of condylar head (80%), and the minor change was effusion (10%), while in controls were an osseous change of condylar head (30%) and condylar head flattening (10%). Osseous changes occur in TMJs of RA patients with mild to moderate symptoms, MRI can be used as an efficient imaging modality for detecting changes in TMJ.



## 1. Introduction

Rheumatoid arthritis (RA) is a chronic, systematic, autoimmune, irreversible, inflammatory disorder of the joints throughout the body characterized by swelling, tenderness, pain and destruction of the joint. The synovium is the key target of the disease process in rheumatoid arthritis (RA). It can be anticipated that examination of synovial tissue samples may provide insight into the pathogenesis of the disease and the mechanism of action of treatment [1].

The temporomandibular joint (TMJ) is a vital organ closely associated with masticatory and swallowing functions, and its damage severely reduces the quality of life. The clinical findings in the TMJ affected by RA are pain, swelling, movement impairment and crepitation; moreover, in advanced stages, malocclusion of the teeth and an anterior open bite may occur [2]. Generally, the TMJ pain complaints in patients with RA were recorded to be higher than 50%, the most frequent being bilateral involvement. However, it is rarely the first joint to be affected, thus, posing diagnostic challenges for the dentist [3].

The frequently observed radiographic changes in RA are joint-space reduction and peripheral erosions, while in the progressive stage, extreme osteolysis and even total damage of the condyle. Although osteophytes are not considered a definite feature of RA, they might be seen, while ankylosis is rare [2].

The most commonly used imaging procedure for assessing the TMJ is MRI, which has more significant benefits than other techniques. MRI can illustrate soft tissue alterations of the TMJ, but their investigative worth for discovering TMJ osseous defects is still debated [4]. Recently, CBCT has been extensively utilized to detect anomalies in the dental area, and its consistency for identifying early degenerative changes of the TMJ has been described widely [5].

In this study, we aimed to determine the frequency and character of TMJ involvement in RA patients and compare the diagnostic efficacy of two imaging modalities (MRI and CBCT) in determining radiographic changes of TMJ.

## 2. Patients and methods

### *2.1 Patients*

Forty patients with RA (38 females and 2 males) were diagnosed at Rheumatology and Rehabilitation Center, Sulaimaniyah Health Directorate, Sulaimaniyah city, Iraq, by a rheumatology specialist according to implement criteria described by the American College of Rheumatology/European League against Rheumatism for classification and assessing the severity of the disease [6] were involved in this study.

Patients were allocated into 2 groups based on their chronicity of RA. The 1$^{st}$ batch (A) includes 20 diagnosed patients that had RA for 1-5 years with a mean age of 49.1 ± 9.48 years, and the 2$^{nd}$ batch (B) includes 20 diagnosed patients that had RA for 6-10 years with a mean age of 52.15 ± 11.37 years. On the other hand, ten healthy females with a mean age of 37.5 ± 6.18 years were included as a control group (C) (Table 1).

**Table 1** Age distribution of study participants.

| Group | No. | Age (Years) | | |
|---|---|---|---|---|
| | | Minimum | Maximum | Mean±SD |
| **A** | 20 | 31 | 66 | 49.1±9.48 |
| **B** | 20 | 30 | 74 | 52.15±11.37 |
| **C** | 10 | 30 | 47 | 37.5±6.18 |
| **Total** | 50 | | | |

A: First group of RA patients, B: Second group of RA patients, and C: Control group.

### *2.2 Inclusion criteria*

Patients diagnosed with RA, those without any other systemic diseases, chronic infection or heavy

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Volume 62, Issue 10, December, 2022

medication, and those willing to participate were included in this study from March 2020 until March 2021.

***2.3 Exclusion criteria***

Patients with psoriatic arthritis, osteoarthritis, history of juvenile RA, taking medication for other systemic diseases (hypertension, diabetes mellitus, hypercholesteraemia, and cancer), pregnant women, patients not willing to participate and those contraindicated to MRI such as those having bullets, metallic objects, pacemaker, insulin pump biostimulator, neurostimulator, cochlear implant, intracranial aneurismal clips and hearing aids.

***2.4 Imaging***

The CBCT was performed by a skilled radiographer under the supervision of a maxillofacial radiologist, and MRI was performed by an experienced radiographer under the supervision of a general radiologist to find changes and abnormalities in TMJs [7].

***2.5 CBCT examination***

CBCT examination was performed with the participant's closed mouth in an occlusal situation with the selected field of view (8.5 cm x 8.5 cm) and 98 kV, 10 mA and 14 seconds exposure time using Sirona 3D machine (Galileos Comfort, Germany). Later on, contiguous sectional images in 3 directions, including the sagittal section (vertical to the long axis of the condylar head), coronal section (parallel to the long axis of the condylar head), and axial (horizontal) section, were done in a Multiplanar Reconstruction (MPR) with a slice thickness of 1 mm using CBCT software (Sidex XG -Gallileos viewer).

CBCT has been proved to be precise enough to supply reliable and clinically relevant data of the TMJ [8], [9], so we used CBCT as a gold standard for comparison with MRI to detect radiographic changes in the TMJ.

***2.6 MRI examination***

After the CBCT examination, an MRI examination was performed in closed mouth and supine posture using a 1.5 Tesla GE machine (made in the USA) that had a head coil with 14 slices, 3.0 mm slice thickness, 1.0 mm inter-slice gap, and FOV of 150*1.2. Scout images (an axial, coronal, and sagittal) were taken at the beginning to localize and plan the sequences. On the axial cuts, a slice was selected on which the condyles of both sides were well depicted. On the sagittal scout, axial cuts were planned parallel to the orbitomeatal line at the level of the auditory canal, and sagittal cuts were perpendicular on the parasagittal plane (long horizontal axis of each condyle), and the condyles were included inside the planned slices. T1 and T2 coronal and sagittal sections and PD sagittal sections were taken separately for right and left TMJs.

T1 coronal sections were planned as follows: the coronal slices planned on axial plane, angle the position block parallel to the right or left condyle of the mandible. T2 coronal section was done with the same planning as the T1 coronal but with different parameters. Whereas, T1 sagittal sections were planned as follows: the sagittal localizers were planned on the axial plane; for the right side localizer angle, the position block was perpendicular to the right condyle of the mandible, and for the left side localizer angle, the position block perpendicular to the left condyle of the mandible. The T2 sagittal section was done with the same planning as the T1 sagittal but with different parameters. Finally, PD sections were planned as follows: the position block was placed parallel to the right or left condyle of the mandible. Slices were sufficient to cover the TMJ from articular eminence up to the line of the internal auditory meatus.

***2.7 Radiographic change finding***

The corrected sagittal and coronal sections of CBCT of each patient were examined by a maxillofacial radiologist (with 15 years of experience) on a computer (Core i5-4460 CPU@3.20 GHz, Ram 8GB and Hard capacity of 840 GB, Windows 10 pro) and the following radiographic changes were recorded: bone erosion (decreased density of cortical bone extending into the bone marrow), flattening (a flat bony contour deviating from the convex form), sclerosis (an area of increased density of cortical bone extending into the bone marrow) and subchondral cyst (A cavity below the articular surface that deviates from normal marrow pattern) [10], [11] (Figure 1).

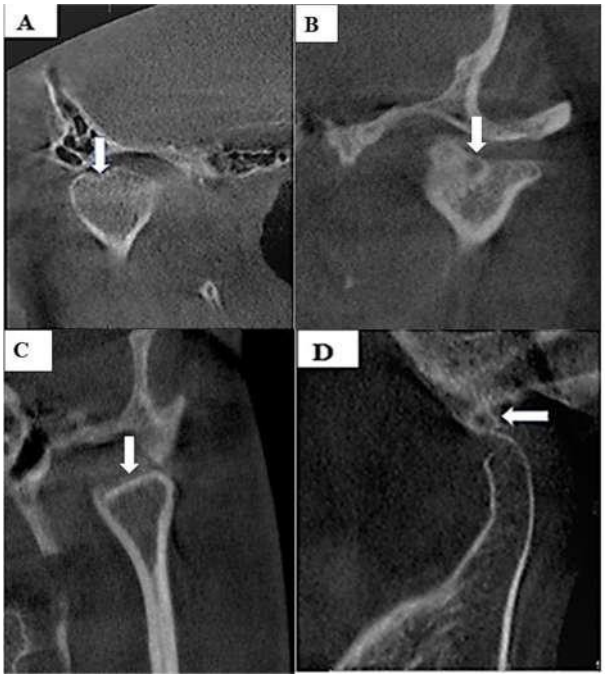


**Figure 1** Shows condylar head erosion (A), subchondral cyst (B), flattening (C), and sclerosis (D).

***2.8 MRI***

The MRI of each patient was examined by a general radiologist (with 16 years of experience) on a computer (Core i5-4300 CPU@31.9 GHz, Ram 8GB and Hard capacity of 240 GB, Windows 10 pro) using Radiant DICOM viewer and the following radiographic changes were recorded: osseous changes of the condyle (abnormal signal intensity of the bone marrow/erosion in the cortex), condylar head flattening, osseous changes in the articular eminence (presence or absence of erosion), joint effusion (identifying thin lines or an area of high signal intensity inside the articular space on T2Weighted image), and synovial proliferation (thickened and widened synovium with intermediate signal intensity) [12], [13] (Figure 2).

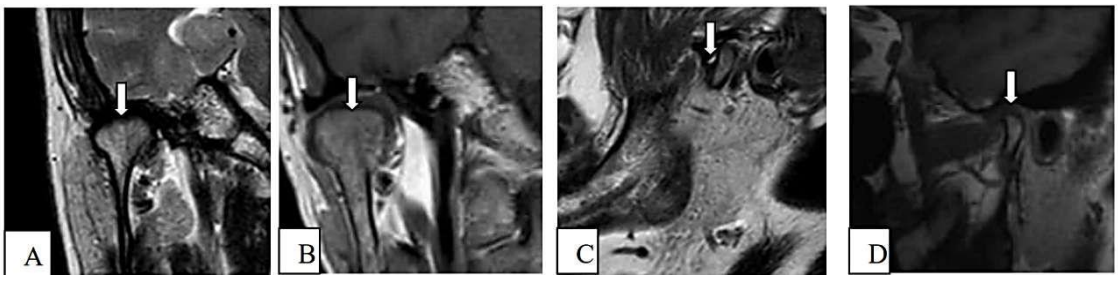


**Figure 2** Shows osseous change of condyle (A), condylar head flattening (B), effusion (C), and synovial proliferation (D).

ISSN: 0005-2523
Volume 62, Issue 10, December, 2022

### *2.9 Statistical analysis*

The collected data were analyzed using IBM SPSS statistics (Statistical Package for Social Sciences), version 26.0 (Chicago, USA). Numerical data were tested for normality of their distribution using the Shapiro-Wilk test. Qualitative data were presented as numbers and percentages. Quantitative data were presented as mean and standard deviation. A student t-test was used for parametric data; an Independent t-test was used for comparison between groups. Pearson correlation coefficients were used to determine correlations between variables. Statistically significant data was considered when probability values of less than 0.05 ($p<0.05$) were obtained.

## 3. Results

### *3.1 Radiological assessment*

The frequency of TMJ involvement using CBCT was 82.5% in RA patients and 50% in the control group, while the frequency was 87.5% in RA patients and 30% in the control group using MRI (Figure 3).

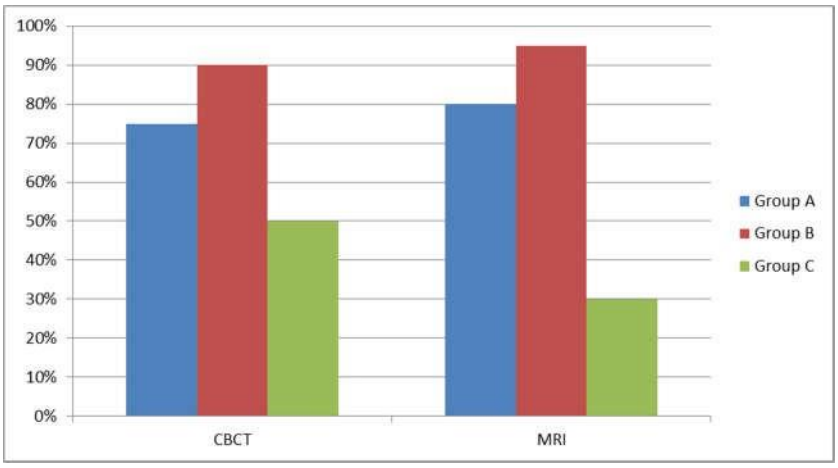


**Figure 3** shows the frequency of TMJ involvement radiographically.
A: First group of RA patients, B: Second group of RA patients, and C: Control group

### *3.2 Radiographic findings on CBCT*

In RA patients, the frequency of condylar head erosion was 70% in group A and 65% in group B, without significant difference (P=0.516). The frequency of articular eminence erosion was 5% in group A and 10% in group B (P=0.032). The frequency of condylar head flattening was 55% in group A and 75% in group B, without significant difference (P=0.834). The frequency of condylar sclerosis was 15% in both groups A and B, without significant difference (P=0.245). The frequency of subchondral cyst was 30% and 5% in groups A and B, respectively, with a significant difference (P=0.000), and there was no osteophyte in both groups. On the other hand, the only observed radiographic change in group C was the flattening of the condylar head (50%) without significant difference with RA patients (P=0.803) (Table 2).

**Table 2** Frequency of radiographic changes by CBCT of all studied groups.

| Group | Condylar Erosion | | | Articular Eminence Erosion | | | Osteophyte | | Sclerosis | | | Subchondral Cyst | | | Flattening | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | No. | % | P-value | No. | % | P-value | No. | % | No. | % | P-value | No. | % | P-value | No. | % | P-value |
| A | 14 | 70 | 0.51 | 1 | 5 | 0.03 | 0 | 0 | 3 | 1 | 0.24 | 6 | 30 | ≤0.0 | 11 | 5 | 0.83 |

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 6 | | | 2 | | | | 5 | 5 | | | 1 | | 5 | 4 |
| **B** | 13 | 65 | | 2 | 10 | | 0 | 0 | 3 | 15 | | 1 | 5 | | 15 | 75 | |
| **Total** | 27 | 67.5 | | 3 | 7.5 | | 0 | 0 | 6 | 15 | | 7 | 17.5 | | 26 | 65 | |
| **C** | 0 | 0 | ≤0.01 | 0 | 0 | ≤0.01 | 0 | 0 | 0 | 0 | ≤0.01 | 0 | 0 | ≤0.01 | 5 | 50 | 0.803 |

### *3.3 Radiographic findings on MRI*

In RA patients, the frequency of condylar head erosion was 75% in group A and 85% in group B. The frequency of articular eminence erosion was 20% in group A and 30% in group B, with no significant difference (P=0.122 and P=0.174, respectively). The condylar head flattening was 30% and 20% in groups A and B, respectively, without significant difference (P=0.367). Moreover, there is no significant difference (P=0.423) in the frequency of synovial proliferation in groups A and B (20%). In comparison, the frequency of effusion was 15% in group A and 5% in group B, with a significant difference (P=0.017). In group C, the most frequent radiographic change was the osseous condylar head (30%) followed by condylar head flattening (10%) with a significant difference with patients (P=0.000 and 0.001, respectively) (Table 3).

**Table 3** Frequency of radiographic changes by MRI in participants.

| Group | Osseous Condyle | | | Osseous Articular Eminence | | | Synovial Proliferation | | | Effusion | | | Condylar Flattening | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | No. | % | P-value | No. | % | P-value | No. | % | P-value | No. | % | P-value | No. | % | P-value |
| **A** | 15 | 75 | 0.122 | 4 | 20 | 0.174 | 4 | 20 | 0.423 | 3 | 15 | 0.017 | 6 | 30 | 0.367 |
| **B** | 17 | 85 | | 6 | 30 | | 4 | 20 | | 1 | 5 | | 4 | 20 | |
| **Total** | 32 | 80 | | 10 | 25 | | 8 | 20 | | 4 | 10 | | 10 | 25 | |
| **C** | 3 | 30 | 0.234 | 0 | 0 | ≤0.01 | 0 | 0 | ≤0.01 | 0 | 0 | ≤0.01 | 1 | 10 | 0.001 |

### *3.4 Comparison between CBCT and MRI outcomes*

Sensitivity and specificity tests were done to compare the diagnostic ability of CBCT and MRI in detecting osseous abnormalities of TMJs, and we revealed that the MRI had a sensitivity of 75% and specificity of 84% to the CBCT test (Figure 4).

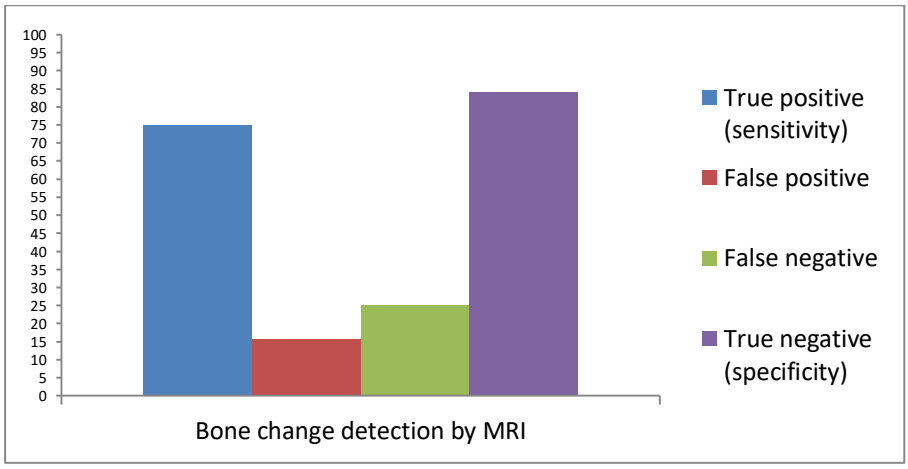


**Figure 4** Sensitivity and specificity of MRI in detecting osseous changes of studied groups.

## 4. Discussion

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This study was done to assess TMJ changes in RA patients and their relative to disease chronicity and to compare the diagnostic effectiveness of CBCT and MRI in detecting radiographic changes of TMJs. There is no international radiographic classification or scoring measurements to evaluate TMJ changes in RA patients [14]. Therefore, we aimed to find TMJ osteoarthritic changes and other bony changes.

In our study, the frequency of TMJ involvement in RA patients was 85%, while it was reported to vary from 2% to 86% in other studies [15- 17]. Such differences might be due to the different types of examination, patient selection criteria, diagnostic techniques and the inclusion criteria. Based on the results of some other studies, the same damaging pathway as found in other joints is also seen in TMJ involvement which is believed to be is straightly related to the severity and extent of RA [18]. These findings are not confirmed by our study and some other studies [19].

***4.1 CBCT finding***

In our RA patients, the most common osseous change was condylar head erosion (67.5%) which was higher than the results of other studies [20], [21] who reported 13.3% and 50%, respectively, and close to the result found by [22] (62.5%) but lower than those found by other studies [23], [24] who reported 72% and 85%, respectively. We detected flattening in both RA and control groups (65% and 50%, respectively) which was close to the results of a study conducted in Egypt [25] found 89.3% and 50%, respectively and higher than the results of [21] who found 30% flattening in RA patients.

Moreover, we found subchondral cyst only in the RA group (17.5%), which was higher than the outcomes of [24] (10%) but was lower than some other researches [20- 22], [25] who reported 32.1%, 23.3%, 30%, and 20.83%, respectively. Furthermore, we found sclerosis in the RA patients (15%), which was much lower than in other studies [21], [22], [25] who reported 64.3%, 75%, and 41.67%, respectively. Such differences between studies might be related to the number of cases, the difference in CBCT machines' quality, and selected TMJ assessment sections.

***4.2 MRI finding***

In our RA patients, the frequency of osseous change of condyle (erosion) was 80% which was in agreement with results found by other studies [26], [27] who reported 80% and 83.3%, respectively, but higher than [28] (52.5%), and lower than the results of a study done in Japan [12] who found erosion in 96% of RA cases. On the other hand, the frequency of articular eminence erosion was 25% higher than the results reported by other studies [27], [12] who found 9.5% and 8.2%, respectively, but lower than the reported result [28] (50%). Whereas the condylar head flattening was seen at 25%, higher than the results found by [28], [27] (15% and 16.6%, respectively).

In our patients, synovial proliferation was found in 20%, different from other studies [27], [12] who reported 100% and 85.7%, respectively. The frequency of effusion was 10% which was much lower than the results of other studies [26], [27], [12], [29] who reported 67.5%, 30.9%, 33%, and 58.3%, respectively. Differences in the results of these studies might be related to differences in MRI techniques, use of contrast media and differences in parameters and selected slices.

***4.3 Comparison of CBCT and MRI***

Many researchers stated the high capacity and superiority of CBCT in evaluating osseous changes of the TMJ over other imaging modalities [30] Due to the remarkable consistency of CBCT established by previous research, we reflected CBCT as a gold standard in estimating osseous damages compared to MRI. However, the investigative capability of MRI to find osseous alterations of the TMJ using cadaver samples

has been evaluated. This study demonstrated that the MRI had 75% sensitivity and 84% specificity in detecting osseous abnormalities. In this regard, evaluation of 106 TMJs was done by CBCT, and MRI and low sensitivity (30 - 82%) with high specificity (84 - 90%) of MRI for detecting osseous abnormalities were seen [31] as well as a study on 20 TMJs were done and sensitivity of 25 - 90.9% with a specificity of 70.8 - 97.2% were found [28]. Generally, the low sensitivity of MRI in detecting osseous abnormalities might be due to the restricted resolution of MRI, and the slice thickness of MRI, as mainly ≥ 3 mm is used, which might be too profuse to identify indirect osseous damages [32]. Additionally, fibrous tissues within TMJ and the connection of the lateral pterygoid muscle nearby the articular surface of the condyle can be explained as either an osseous anomaly or as a disc. They may result in false-positive or negative findings. [33]. Finally, when identifying osseous deformities in the articular fossa and eminence, complications sometimes arise by the magnetic susceptibility artefacts [34], [35].

## 5. Conclusions

Osseous changes such as erosions are associated with TMJs affection in RA patients that might occur with mild to moderate clinical signs. Thus, TMJ imaging must be done for RA patients to avoid severe complications even if there are no clinical signs. MRI can be used as an excellent diagnostic imaging modality compared to CBCT due to its high sensitivity and specificity in detecting osseous changes of the TMJs.

Declarations

Ethics approval and consent to participate

All experiments in this study were performed according to relevant guidelines and regulations belonging to the declaration of Helsinki for using human tissues and it was registered in the German Clinical Trails Register (DRKS) belongs to the World Health Organization (WHO) clinical trial registration official with ID No. (DRKS00024167). Additionally, our study protocol was approved by the Ethical Committee of the College of Medicine, University of Sulaimani, the Republic of Iraq, with no. 105 on 27/1/2020. Furthermore, informed written consent was obtained from all subjects.

Consent for publication

Not applicable.

Availability of data and materials

All data generated or analyzed during this study are included in this published article.

Competing interest

The authors declare no conflict of interest in this research study.

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Author's contributions

RAJ: Conceptualization, data collection and analysis, writing the original manuscript; KMA: Visualization, supervision, validity, manuscript edition and correction; SMA: Resources, supervision, study registration and administration.

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ISSN: 0005-2523
Volume 62, Issue 10, December, 2022

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