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ORIGINAL ARTICLE

3D CBCT morphometric assessment of mental foramen in Arabic population and global comparison: imperative for invasive and non-invasive procedures in mandible

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ABSTRACT

Background: Recent advancements in clinical dentistry have increased the possibilities of surgical procedures in the mental region. A detailed knowledge of mental foramen (MF) morphometry is significant to preserve integrity of the mental nerve trunk in surgical interventions such as orthognathic surgery, implant placement and anaesthetic block.

Objective: The aim of this study was to determine the most accurate position of the mental foramen by using new assessment approach in a sample of dental patients presenting to the specialist dental clinic, College of Dentistry, Al Jouf University, Saudi Arabia.

Study design: A retrospective study was performed using cone beam computed tomography (CBCT) of 600 patients (40.1 ± 11.78 years old). Following inclusion and exclusion criteria, 395 CBCT were finally obtained and analyzed for the most accurate position of the mental foramen (MF) by OnDemand 3D software (Seoul, Korea). Prevalence of shape of MF and accessory MF were also assessed. Pearson chi-square test was employed to test significant differences between genders and races.

Results: The most common horizontal and vertical position of the mental foramen was in line with the long axis of 2nd premolar (41.3%) and below the root apex level (93.2%), respectively. The most common shape of MF was round type (72.66%). The prevalence of accessory 2MF and 3MF was 2.28% and 0.25%, respectively.

Conclusion: New information about MF presented in this article can help anatomists, prosthodontists, orthodontists, surgeons, forensic odontologists and paleoanthropologists to predict the position of the MF and perform safer surgeries.

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Mental foramen; accessory mental foramen; anatomic position; CBCT; mandible

Introduction

Mental foramen (MF) transmits the mental vessels and nerve that provide blood supply and sensory innervation to the chin, lower lip and gingiva on the ipsilateral side of the mandible [1]. Knowledge of accurate position of MF is very important for any invasive and non-invasive procedure near MF area [2]. During implant placement, periapical surgery and orthognathic surgery, mental nerves and vessels can be traumatized. Recently, implant technique and frequency of orthognathic surgery has increased the chances of surgical procedures near MF area [3], as well as injury to the mental bundle [4]. As a result, it can cause temporary or permanent sensorial, tactile or thermal impairment [4,5].

Accessory mental foramen (AMF) is a rare variation and may be present in the 1st molar tooth area [5]. Sawyer et al. have reported ethnic variations in the incidence of AMF [6]. Knowledge of the AMF is important for performing surgeries and regional anaesthesia blocks.

Various techniques have been in use for the pre-surgical evaluation of mental foramen. Cone beam computed tomography (CBCT) has attained popularity in recent years because of its ability to view the entire body of the mandible which allows a more accurate determination of the position of MF in horizontal and vertical dimensions [7]. Since CBCT is a three-dimensional image, it is more accurate to interpret compared to conventional radiography.

Gender and racial disparities in the position of mental foramen have been reported in literature [1–7]. In multi-ethnic societies, comparison of mental foramen position among different racial/ethnic groups is important from a clinical perspective. To date, no data are available on the differences in the position, size and shape of MF between various ethnic groups living in Saudi Arabia. Hence, the aims of this study were to:

- identify the accurate position of MF.
- determine gender disparities in different positions of MF.

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- determine racial disparities in different positions of MF.
- determine side disparities in different positions of MF.
- determine gender disparities in symmetry and asymmetry of MF.
- determine racial disparities in symmetry and asymmetry of MF.
- determine the gender and side disparities in different shapes of MF.
- determine the racial disparities in different shapes of MF.
- identify the prevalence of accessory MF.

Materials and methods

This study was approved by the Ethics Committee of the College of Dentistry, Al Jouf University.

Written informed consent was obtained from each patient before taking a CBCT. Out of 600 CBCT of patients attending the specialist dental clinic, Al Jouf University, applying the strict selection criteria such as, good quality CBCT with high volumetric data and patients without craniofacial deformity and history of any surgical procedure in the mandible, 395 (127 females and 268 males) were selected from the digital archives.

Three vertical lines were drawn on the longitudinal axis of 1st premolar, 2nd premolar and mesial root of 1st molar, respectively, to identify the horizontal position of MF [8]. To identify the vertical position of MF, a horizontal line was drawn connecting the apices of 1st and 2nd premolars.

The horizontal position of the MF was measured as follows (Figure 1) [8]:

Position 1 (P1) – Situated mesial to the long axis of 1st premolar.
Position 2 (P2) – Situated in line with the long axis of 1st premolar.

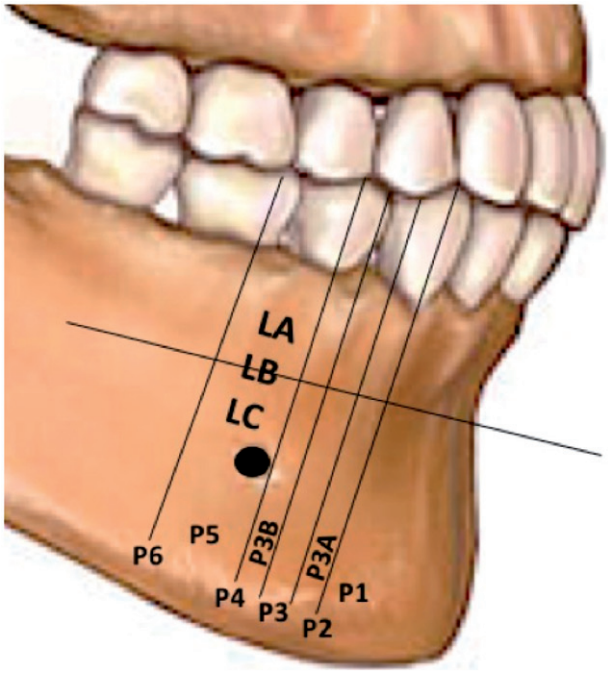

Figure 1. Graphical representation of the measurements of vertical and horizontal position of MF obtained in this study.

Position 3A (P3A) – Mesial 1/3 of position between the long axis line of the 1st and 2nd premolar.
Position 3 (P3) – Middle 1/3 of position between the long axis line of the 1st and 2nd premolar.
Position 3B (P3B) – Distal 1/3 of position between the long axis line of the 1st and 2nd premolar.
Position 4 (P4) – Situated in line with the long axis of 2nd premolar.
Position 5 (P5) – Between the long axis of the 2nd premolar and mesial root of the 1st molar.
Position 6 (P6) – Situated in line with the long axis of mesial root of 1st molar.

The vertical position of MF was measured as follows (Figure 1) [8]:

Level A (LA) – Above the horizontal line.
Level B (LB) – At the horizontal line.
Level C (LC) – Below the horizontal line

We followed the modified method proposed by Zaman et al. [8]. for the assessment of horizontal and vertical positions of MF. However, Zaman et al. [8] assessed by orthopantomogram. MF was classified as round and oval shape by single examiner. These shapes were classified on their gross appearance in the CBCT images. MF was considered 'round' if they appeared circular in shape, i.e. the dimension was equidistant in both width and height, while they were considered 'oval' if they had a circular shape which was wider in one direction than the other. Finding more than one MF was classified in the AMF group.

Statistical analysis

IBM SPSS, version 22.0 (SPSS, Chicago, IL) was used for statistical analysis. Pearson chi-square test was employed to determine the prevalence of MF and significant differences between genders and races. Differences were considered significant at a p value $<.05$. 20% of the CBCT data was re assessed by two examiners to check the reliability of the assessment. Kappa statistics were applied to test the intra- and interexaminer reliability.

Results

Error study results

A very good agreement was found between intra- and interexaminer reliability. Intra-examiner reliability of Examiner A was 0.92 and 0.94 for the Examiner B. Interexaminer reliability for the Examiner A vs. B was 0.89.

Gender disparities

This study utilized the 395 CBCT samples; gender distributions of position of the right- and left-sided MF in horizontal and vertical relation are summarized in Tables 1–4. No significant disparities were observed when right side was

Table 1. Gender distribution of position of the right-sided mental foramen in horizontal relation to the apices of teeth and interdental space on the CBCT of 395 patients.

	Male		Female		Total	
Horizontal position	Frequency	%	Frequency	%	Frequency	%
P1	2	0.7	0	0.0	2	0.5
P2	3	1.1	0	0.0	3	0.8
P3A	9	3.4	0	0.0	9	2.3
P3	29	10.8	14	11.0	43	10.9
P3B	61	22.8	40	31.5	101	25.6
P4	118	44	45	35.4	163	41.3
P5	44	16.4	27	21.3	71	18
P6	2	0.7	1	0.8	3	0.8
Total	268	100	127	100	395	100

Table 2. Gender distribution of position of the left-sided mental foramen in horizontal relation to the apices of teeth and interdental space on the CBCT of 395 patients.

	Male		Female		Total	
Horizontal position	Frequency	%	Frequency	%	Frequency	%
P1	1	0.4	0	0.0	1	0.3
P2	3	1.1	0	0.0	3	0.8
P3A	6	2.2	5	3.9	11	2.8
P3	26	9.7	17	13.4	43	10.9
P3B	68	25.4	33	26	101	25.6
P4	115	42.9	43	33.9	158	40
P5	47	17.5	28	22	75	19
P6	2	0.7	1	0.8	3	0.8
Total	268	100	127	100	395	100

Table 3. Gender distribution of position of the right-sided mental foramen in vertical relation to the apices of teeth on the CBCT of 395 patients.

	Male		Female		Total	
Vertical position	Frequency	%	Frequency	%	Frequency	%
LA	1	0.4	2	1.6	3	0.8
LB	15	5.6	9	7.1	24	6.1
LC	252	94	116	91.3	368	93.2
Total	268	100	127	100	395	100

Table 4. Gender distribution of position of the left-sided mental foramen in vertical relation to the apices of teeth on the CBCT of 395 patients.

	Male		Female		Total	
Vertical position	Frequency	%	Frequency	%	Frequency	%
LA	2	0.7	2	1.6	4	1
LB	12	4.9	5	3.9	17	4.3
LC	254	94.8	120	94.5	374	94.7
Total	268	100	127	100	395	100

compared to left side. P4 was the most prevalent (41.3%) position of the MF on the right side. In relation to gender, males showed highest prevalence of P4; however, females showed P3 (when combined with P3B) (Table 1). Similar results were obtained for the horizontal position of MF on the left side (Table 2). In relation to vertical position, L3 was the most prevalent position of MF on both right (male = 94% and female = 91.3%) and left sides (male = 94.8% and female = 94.5%) (Tables 3 and 4). Symmetrical position of MF was the most common in both males (65%) and females (59%) (Table 5).

Table 5. Gender distribution of symmetrical and asymmetrical position of mental foramen on the CBCT of 395 patients.

	Male		Female		Total	
	Frequency	%	Frequency	%	Frequency	%
Symmetrical	174	64.9	75	59.1	249	63
Asymmetrical	94	35.1	52	40.9	146	37
Total	268	100	127	100	395	100

Table 6. Racial distribution of position of the right-sided mental foramen in horizontal relation to the apices of teeth and interdental space on the CBCT of 395 patients.

	Saudi		Jordan		Egypt	
Horizontal position	Frequency	%	Frequency	%	Frequency	%
P1	2	0.6	0	0.0	0	0.0
P2	2	0.6	0	0.0	1	3.1
P3A	9	2.8	0	0.0	0	0.0
P3	38	11.8	3	7.1	2	6.2
P3B	91	25.2	12	28.6	8	25
P4	129	40.2	19	45.2	15	46.9
P5	57	17.8	8	19	6	18.8
P6	3	0.9	0	0.0	0	0.0
Total	321	100	42	100	32	100

Table 7. Racial distribution of position of the left-sided mental foramen in horizontal relation to the apices of teeth and interdental space on the CBCT of 395 patients.

	Saudi		Jordan		Egypt	
Horizontal position	Frequency	%	Frequency	%	Frequency	%
P1	1	0.3	0	0.0	0	0.0
P2	1	0.3	0	0.0	2	6.2
P3A	11	3.4	0	0.0	0	0.0
P3	40	12.5	3	7.1	0	0.0
P3B	78	24.3	16	38.1	7	21.9
P4	126	39.3	15	35.7	17	53.1
P5	62	19.3	8	19	5	15.6
P6	2	0.6	0	0.0	1	3.1
Total	321	100	42	100	32	100

Table 8. Racial distribution of position of the right-sided mental foramen in vertical relation to the apices of teeth on the CBCT of 395 patients.

	Saudi		Jordan		Egypt	
Vertical position	Frequency	%	Frequency	%	Frequency	%
LA	3	0.9	0	0.0	0	0.0
LB	20	6.2	2	4.8	2	6.2
LC	298	92.8	40	95.2	30	93.8
Total	321	100	42	100	32	100

Racial disparities

Racial distributions of position of MF on both sides and in horizontal and vertical relation are summarized in Tables 6–9. No significant disparities were observed among Saudi, Jordanian and Egyptian populations. Based on the modified classification, P4 position of MF had the highest prevalence for all three races on right side. For Saudi, Jordanian and Egyptian populations, the prevalence of right-sided MF P4 position was 40.2%, 45.2% and 46.9%, respectively (Table 6). Similar results were revealed in relation to the position of left-sided MF in horizontal relation. Although the Egyptian

Table 9. Racial distribution of position of the left-sided mental foramen in vertical relation to the apices of teeth on the CBCT of 395 patients.

	Saudi		Jordan		Egypt	
Vertical position	Frequency	%	Frequency	%	Frequency	%
LA	3	0.9	0	0.0	1	3.1
LB	15	4.7	1	2.4	1	3.1
LC	303	94.4	41	97.6	30	93.8
Total	321	100	42	100	32	100

Table 10. Racial distribution of symmetrical and asymmetrical position of mental foramen on the CBCT of 395 patients.

	Saudi		Jordan		Egypt	
	Frequency	%	Frequency	%	Frequency	%
Symmetrical	196	61.1	34	81	19	59.4
Asymmetrical	125	38.9	9	19	13	40.6
Total	321	100	42	100	32	100

Table 11. Distribution of accessory mental foramen on the CBCT of 395 patients.

Number of MF	Frequency	%
0	0	0
1	385	97.47
2	9	2.28
3	1	0.25
Total	395	100

Table 12. Gender distribution of round and oval shape mental foramen on the CBCT of 395 patients.

	Male		Female		Total	
	Frequency	%	Frequency	%	Frequency	%
Round	192	71.64	95	74.80	287	72.66
Oval	76	28.36	32	25.20	108	27.34
Total	268	100	127	100	395	100

Table 13. Racial distribution of round and oval shape mental foramen on the CBCT of 395 patients.

	Saudi		Jordan		Egypt	
	Frequency	%	Frequency	%	Frequency	%
Round	239	74.45	32	76.19	24	75
Oval	82	25.55	10	23.81	8	25
Total	321	100	42	100	32	100

population showed higher prevalence (53.1%), the differences were not significant (Table 7). In relation to vertical position, right- and left-sided MF for Saudi, Jordanian and Egyptian populations, L3 had the highest prevalence (92.8%, 95.2% and 93.8%, respectively) (Tables 8 and 9).

Racial disparities in the symmetry of MF were also observed. Symmetrical position showed the highest prevalence, although the prevalence varied in the three racial groups (Saudi = 61.1%, Jordan = 81% and Egypt = 59.4%). Differences were not statistically significant (Table 10).

Accessory mental foramen

Out of 395 patients, only 10 AMF were observed. All 10 AMF were found in Saudi population only. Nine patients had two MFs and in one patient three MFs were found (Table 11).

Shape of mental foramen

Gender and racial distributions of shape of MF are shown in Tables 12 and 13. Round-shaped MF showed the highest prevalence.

Discussion

The novelty of the current study stands upon the following points: (i) 395 CBCT data; (ii) three different racial data; (iii) assessment of MF position using a new approach; and (iv) assessment of position, symmetry, shape and accessory canals. This study assessed the overall morphometry of MF which is imperative for invasive and non-invasive procedures in the mandible.

MF is one of the most important landmarks of mandible and determination of its position has gained interest from different fields of study. Determination of its location, shape, size and distances from other important anatomic landmarks and roots of adjacent teeth has been the subject of many studies [2–4,9–11]. From a clinical point of view, sufficient local anaesthesia for dental treatments and safety of surgical procedures in this area are affected by the clinician's knowledge of the position of MF. It can also play a role in the interpretation of anatomical landmarks in forensic sciences [11].

A crucial advantage of CBCT is that it overcomes the limitations of conventional radiography by producing a 3D image of the bone and its landmarks that allow a comprehensive evaluation of the anatomy of the region of interest [6]. To the best of our knowledge, sample size of the current study to determine accurate position of MF is the largest compared to similar studies conducted in other populations [1–7]. In addition, most of these studies use orthopantomogram and skull for the assessment. The new approach of assessment [8] could help the clinicians to determine accurate position of MF for safe invasive and non-invasive procedures in the mandible.

This study followed the same modified approach used by Zaman et al. to study the horizontal position of MF [8]. The current study revealed that the most common horizontal position of MF in Saudi, Jordanian and Egyptian populations was in line with the long axis of 2nd premolar. This finding agrees with other studies [9,12–16]. However, other authors have reported that the most common horizontal position of MF was between the long axis of 1st and 2nd premolars [17–20].

Figure 2 [8,12,15,17,21–35] shows the global prevalence comparison of the horizontal position of MF. The prevalence of horizontal position of MF varies from 40.2 to 73.2. Almost all studies showed higher prevalence of horizontal position of MF is P4 except for the Indian population (P5), European population (P3) and in one study from Iranian population (P3). It is interesting to note that the present study shows lowest prevalence compared to other population. These population variations should be carefully considered during invasive and non-invasive procedures in the mandible.

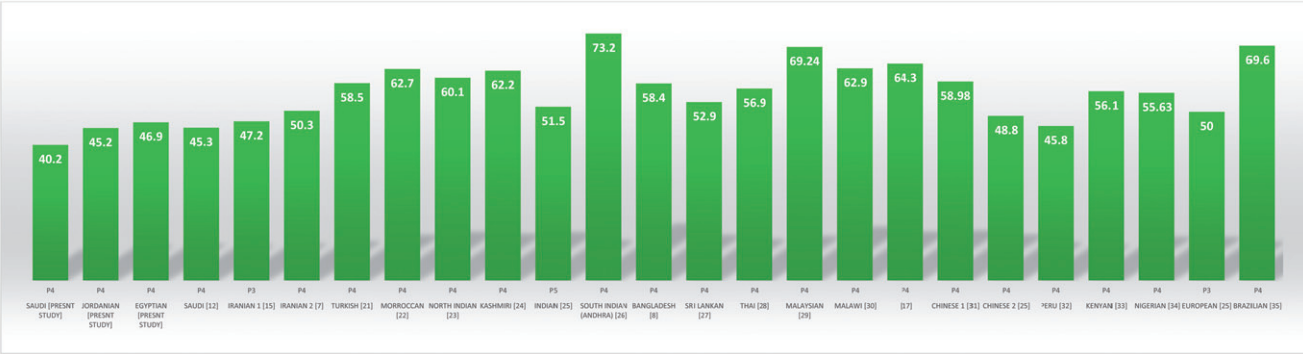

Figure 2. Global prevalence comparison of the horizontal position of MF.

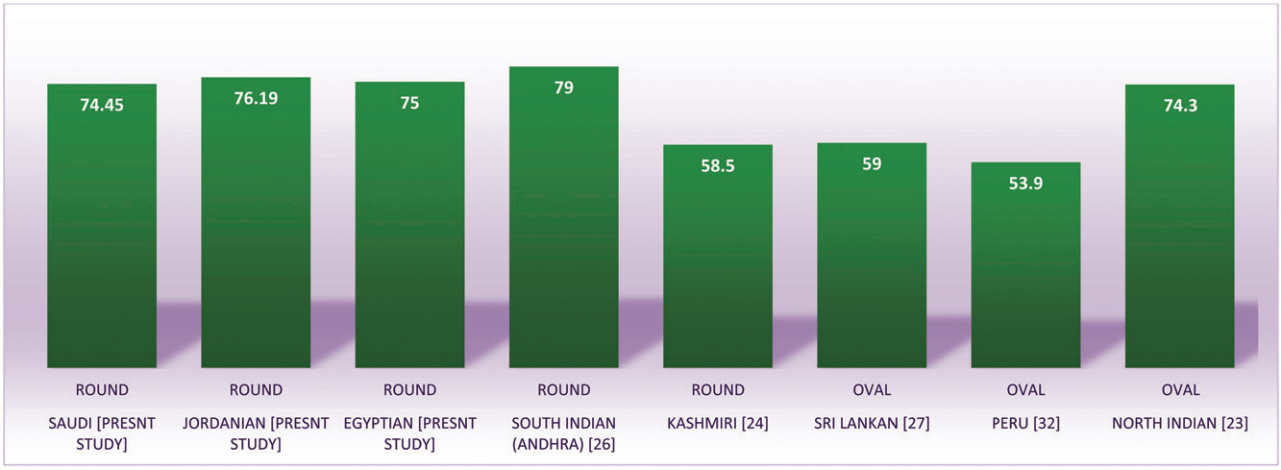

Figure 3. Global prevalence comparison of the shape of MF.

The most common vertical position of the MF was found below the level of horizontal line in Saudi, Jordanian and Egyptian population (Level C – 94.4%, 97.6 and 93.8, respectively), which was drawn from the apex of the 1st premolar to 2nd premolar. These findings were similar with Zaman et al. [8] and Al-Juboori et al. [2]. In addition, the order of frequency for vertical position of MF was LC > LB > LA. It is worthwhile to note that there was no significant difference between genders and races for horizontal and vertical position of MF.

The position of MF was mostly symmetric in Jordanian population (81%), Saudi (61.1%) and Egyptian population (59.4%) and the prevalence of asymmetric MF in Saudi, Egyptian and Jordanian population was 38.9%, 40.6% and 19%, respectively. Lower percentage of symmetry was also found in some other studies [12,36]. Zaman et al. [8] found the prevalence of symmetric position which was near to the Jordanian population. The variation in the position of MF in different population may be due to different genetic variations and/or due to a lag in prenatal growth [29].

Figure 3 [23,24,26,27,32] shows the global prevalence comparison of the shape of MF. Shape of MF varies among populations. Saudi, Jordanian, Egyptian and South Indian population has higher prevalence of round-shaped MF, whereas Sri Lankan, Peru and North Indian had oval shape. Surgeon should keep in mind such variations during implant placement or any other surgical procedure close to MF region.

Figure 4 [7,26,27,33,37] shows the global prevalence comparison of the AMF. AMF varies among populations (2.28–10%). Saudi population had the lowest prevalence, while Jordanian population had the highest prevalence of AMF.

Such differences are interesting; perhaps, the difference in results could be linked to racial or genetic variations or could be due to larger sample size in the Jordanian study. Extra precautions should be taken in such cases as AMF can hinder the success of local anaesthesia and other surgical procedures

The current study is of importance to clinicians and anthropologists for a better assessment of MF position. Based on our findings, clinicians can more accurately estimate the position of MF and perform safer surgeries. Clinicians should modify their surgical techniques in the region of MF to avoid nerve injuries.

Conclusions

Based on the findings of our study, following conclusion can be drawn:

- The most prevalent position of MF is P4 and LC.

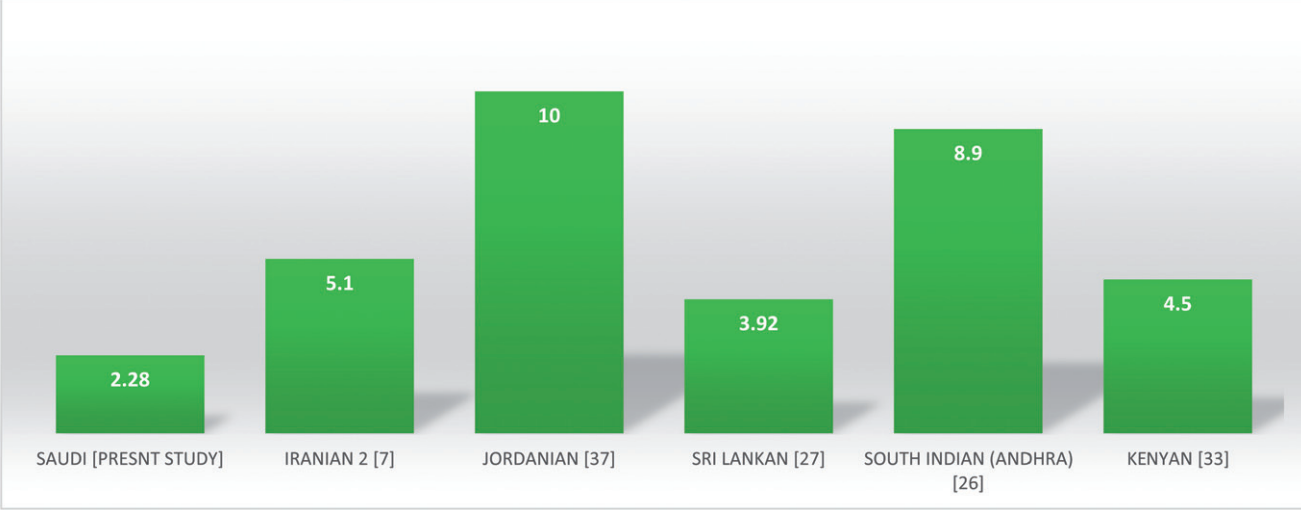

Figure 4. Global prevalence comparison of the AMF.

- Gender disparities in different positions of MF of male and female were P4 and P3 (P3A + P3 + P3B), respectively, and vertical position was LC for both.
- Racial disparities in different positions of MF of Saudis, Jordanians and Egyptians were P4 for Saudi and Egypt, but for Jordan, it was P3 (P3A + P3 + P3B) and P4 and vertical position was LC for all.
- Side disparities in different positions of MF of right and left side were P4 and LC.
- Asymmetry of MF was more frequently found in females.
- Across the parameters of the study, round-shaped MF was more prevalent than the oval-shaped MF.
- The prevalence of accessory MF was 2.53%. For 2 AMF and 3 AMF, it was 2.28% and 0.25%, respectively.

Disclosure statement

No potential conflict of interest was reported by the authors.

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