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Labial Cortical Bone Thickness in the Anterior Region: A Systematic Review

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Abstract

Context: The labial cortical bone may influence the outcomes of several treatments including fresh socket implant placement and orthodontic treatments. A thin labial plate may contribute to increased risks of periodontal consequences during dental procedures. Acknowledgment of the average values may guide clinicians to take particular considerations in making treatment decisions. Therefore, this study aimed to systematically review the labial cortical bone thickness (LBT) in the anterior maxillary teeth.
Objective: The primary purpose of this study was to review the LBT in the anterior maxillary teeth to present the range of average LBT in the global population.
Evidence Acquisition: An electronic search was conducted in PubMed, Embase, ProQuest, Web of Science, and Scopus databases. English studies that measured the LBT in the maxillary anterior teeth using CT or CBCT scans were deemed relevant. Only studies performed on adult patients with a lack of periodontal disease were included.
Results: A total of 49 studies were included. Mean LBT ranged 0.13 - 3.08, 0.29 - 4.2, and 0.36 - 4.5 mm in maxillary central incisor, lateral incisor, and canine, respectively. Expectedly, LBT was affected by the vertical level of the measurement point and increased toward the apex. In total, the LBT in the anterior maxilla ranged from 0.13 to 4.5 mm. In comparison with other populations, a relatively thin labial plate was evidenced in the Iranian populations.
Conclusions: This study showed a wide range of LBT in the esthetic zone. A thin plate in the esthetic area necessitates caution in orthodontic treatments, particularly when tooth expansion or proclination is required. Additionally, wide ranges of reported values which are mostly under 2 mm, highlight the importance of CBCT acquisition before any fresh socket implant placement.

Keywords: Tooth, Buccal Alveolar Bone Thickness, Tomography, X-Ray Computed, Cone-Beam Computed Tomography

1. Context

1.1. Background

Performing dental treatments require a comprehensive perspective regarding periodontal compartments as well as teeth structure. The alveolar plate surrounding teeth is an important part of the periodontium maintaining the teeth within the socket. Additionally, the labial side of the alveolar bone is esthetically important in the anterior maxillary teeth. The labial cortical bone thickness (LBT) may determine outcomes of several procedures such as fresh socket implant placement as well as orthodontic treatments (1-5).

The risk of bone and soft tissue resorption is an inevitable part of several orthodontic treatments, namely in tooth expansion, deep bite correction, and proclination of the anterior teeth (2, 6-9). To avoid such consequences, paying attention to the primary bone structure is crucial before the treatment planning. In cases with a thin plate, extreme caution is recommended (1-3).

Fresh socket implant placement, on the other hand, is another matter of concern with regard to the labial plate dimensions. Minimum width of 2 mm is suggested to avoid prospective bone resorption and complicated esthetic results (4, 5). Indeed, the LBT is a determinant factor to successful outcomes in fresh socket implant placement. In cases with a thinner bone plate, bone augmentation should be considered.

Regarding its importance on several clinical occasions, acknowledgment of the average LBT may guide clinicians to take necessary considerations in clinical decisions. Numerous original studies have measured the LBT in various populations and reported a wide range of values. Regarding this and the lack of a previous systematic review, this study aimed to systematically review the LBT in the anterior maxillary teeth.

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1.2. Objective

The primary purpose of this study was to review the LBT in the anterior maxillary teeth to present the range of average LBT in the global population.

2. Evidence Acquisition

This study was performed based on PRISMA (preferred reporting items for systematic review and meta-analysis) protocols (10).

2.1. Eligibility Criteria

The following inclusion criteria were applied:

- Population: Periodontally healthy patients over the age of 15.

- Intervention: No actual intervention was considered, but rather the acquisition of CT and CBCT scans for measurement of the LBT.

- Comparison: Not applicable.

- Outcome: The range of mean LBT in the anterior maxillary teeth.

The following exclusion criteria were applied: (1) review articles; (2) case series and case reports; (3) patients with skeletal deformities; (4) studies that used two-dimensional radiographs instead of CT or CBCT; (5) studies performed on a dry skull; and (6) studies that only measured the LBT in implants or teeth other than the anterior maxillary teeth.

2.2. Information Sources and Study Selection

A thorough electronic search was carried out in PubMed, Embase, and Web of Science databases. ProQuest Dissertation and Thesis Database was also searched for the gray literature. The search was performed to find relevant studies from the beginning to April 2020 using different combinations of the following keywords: tooth [MeSH], labial bone, alveolar bone, thickness, "Cone-Beam Computed Tomography"[MeSH], and "Tomography, X-Ray Computed"[MeSH]. Only English literature was included and no publication time restriction was applied.

All records were exported to EndNote X9 (Clarivate Company, Philadelphia, USA) for removing duplicates and screening. The screening was conducted first on title and abstracts, followed by full texts. Two independent reviewers conducted the screening process. Any possible disagreements were solved by discussion.

2.3. Data Extraction and Synthesis

Data extraction was piloted based on the instructions of the Cochrane Handbook for Systematic Reviews (11), with some modifications. One reviewer extracted the data and the other reviewer checked for possible mistakes. The following data were extracted from each article: Author's name (publication year), population nationality, tooth type, sample size, references of measurements, and results (mean LBT). The extracted data were gathered and summarized in table and text in terms of the ranges of reported values.

2.4. Risk of Bias Assessment of Studies

Quality assessment of the studies was performed by two independent reviewers using a modification of the appraisal tool for cross-sectional studies (AXIS) (12). The checklist consisted of 10 items for evaluation of study design, method, results, and ethical considerations.

3. Results

3.1. Study Selection

A total of 702 articles were retrieved after the removal of duplicate records. Through screening of titles and abstracts, 67 studies were deemed relevant. Seventeen articles were excluded based on the following reasons: (1) no evaluation of the LBT in anterior maxillary teeth (n = 7), (2) invalid measurement method (n = 3), (3) no full text available (n = 2), (4) biased sample selection (n = 2), (5) two-dimensional radiographs (n = 1), (6) periodontal patients (n = 1), and (7) no evaluation of the labial plate (n = 1). Finally, 49 studies met the inclusion criteria, and the remaining articles were excluded. A flow diagram of the screening process including the exclusion reasons is demonstrated in Figure 1.

3.2. Study Characteristics and Risk of Bias

Study results and characteristics are summarized in Table 1. Studies were mostly performed on the Asian ethnicity such as Chinese and Korean populations. Three out of 49 studies were from Iranian databases (13-15). The total sample was comprised of 4413 patients. Measurements were performed at various reference levels from CEJ, bone crest, and the apex. Table 2 demonstrates the summary risk of bias of the studies. Sample size justification was at the highest risk of bias.

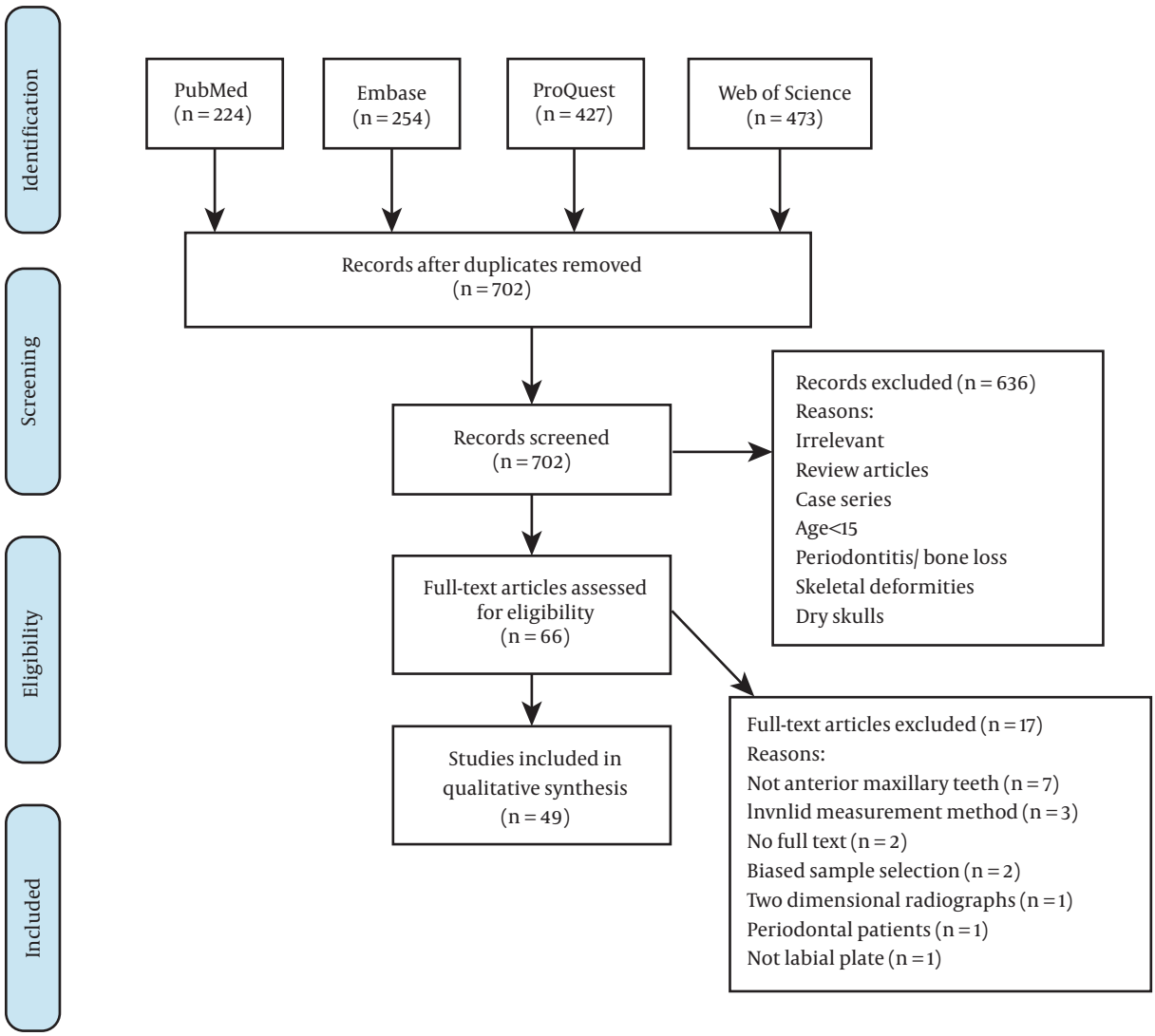


Figure 1. Preferred reporting items for systematic reviews and meta-analyses (PRISMA) (Moher et al. 2009) flow diagram.

3.3. Result of Individual Studies

In general, the mean LBT ranged from 0.13 to 4.5 mm in different studies. Average LBT ranged 0.13 - 3.08, 0.29 - 4.2, and 0.36 - 4.5 mm in maxillary central incisor, lateral incisor, and canine, respectively. The lowest value was reported at the mid-root of the central incisor in a Chinese population (54). While the greatest value was evidenced at the canine apex in a Korean population (34). In the Iranian population, the LBT ranged from 0.29 to 1.79 mm (13-15). The ranges of average LBT reported for the European, American, African, and Asian populations were 0.45 - 3.94, 0.28 - 2.13, 0.48 - 1.5, and 0.13 - 4.5 mm, respectively.

4. Discussion

Considering the importance of LBT values in various clinical occasions such as dental implant placement and orthodontic treatments, this systematic review was performed on studies that measured the LBT in the esthetic region. A total of 49 studies were included, comprising a total sample size of 4413 patients.

The average LBT varied greatly (0.13 - 4.5 mm) based on the population origin, tooth type, and reference of measurement. The range of average values was narrated in each population separately, namely in the Iranian population (0.29 - 1.79 mm). This indicates that the ethnic variations in the anatomical structure of the alveolar bone

should be considered while making clinical decisions potentially affecting the periodontium.

In addition to ethnicity, several factors that potentially affect the LBT should be taken into consideration. Cook et al. showed that LBT is significantly higher in teeth presenting a thick periodontal biotype (20). The LBT also varies based on tooth position and labiolingual inclination (23, 37). Considering these factors might be affected by ethnicity, they may result in variations in the LBT between different populations and should be taken into account in clinical situations.

The labial plate showed the lowest thickness at the crestal levels and thickened toward the apex. A thin labial plate at the middle areas of the tooth axis is associated with increased risks of dehiscence and fenestration during orthodontic treatments (2, 3, 62, 63). On the other hand, a thin plate at the crestal regions increases the risk of bone loss during and after the treatment (1-3, 63). Therefore, even in the presence of an acceptably thick plate in the crestal regions, a possible thinned plate at the middle areas should be taken into consideration in the treatment planning. Based on the reported values, the central incisors were at the highest risk. Except at the apex, most values were under 2 mm, which indicates bone regeneration before any fresh socket implant placement at the esthetic region. additionally, the wide range of reported values indicates the necessity of CBCT acquisition before the tooth extraction and the subsequent implant placement.

There are several limitations to this study. Based on different measurement methods and the variety of references used in different studies, pooling the data through the meta-analysis was not possible. Additionally, various sample populations with different races, ages, and gender proportions may contribute to sources of heterogeneity. It was not evaluated in several studies whether the patients had undergone orthodontic treatments, which may also affect the labial plate dimensions. It is highly recommended for future studies to eliminate such confounding factors in their inclusion process and report that in their study.

5. Conclusion

This study suggests a thin plate in the esthetic area which ranged from 0.29 to 4.2 mm. The presence of a thin labial plate necessitates careful considerations in orthodontic treatment planning to prevent detrimental consequences to the periodontal compartments. Besides a most reportedly thin plate at the crestal regions, the great variations in the range of LBT highlight the importance of CBCT assessment before fresh socket implant placement.

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Footnotes

Authors' Contribution: M.S., contributed to data acquisition and analysis, study design, and drafting of the manuscript; A.T., contributed to study design, data interpretation, and critical revision of the manuscript; S.M., contributed to study supervision, study concept, and critical revision.

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Table 1. Summary Articles

Study Author (Year)	Nationality	Age (Range or Mean)	Teeth	Patients Number	Reference of Measurement	Ranges of Average LBT (mm)
Alsaffar (2016) (16)	Saudi Arabia	NR	U1, U2, U3	30	Mid-root	0.4 - 0.91
Amid (2017) (15)	Iran	NR	U1, U2, U3	144	2, 4, 6mm below CEJ	0.29 - 1.1
Arief (2013) (17)	Malaysia	21 - 50	U1, U2, U3	26	Apex, 3mm below CEJ, mid-root	1.1 - 1.8
Batista (2012) (18)	Brazil	29 ± 3.2	U1, U2, U3	14	1mm below crest	1 - 1.1
Behnia (2015) (14)	Iran	28 - 68	U1, U2, U3	18	Labial bone at 1, 4, 8mm and palatal bone at 1, 4mm below crest	0.66 - 1.79
Braut (2011) (19)	Switzerland	17 - 84	U1, U2, U3	125	4mm below CEJ, mid-root	0.45 - 0.65
Cook (2011) (20)	USA	NR	U1, U2, U3	60	4, 6, 8, 10mm below CEJ	0.28 - 1.2
Demircan and Demircan (2015) (21)	Turkey	18 - 84	U1, U2	60	1, 2, 5mm below crest	0.61 - 1.04
Ding (2013) (22)	China	18 - 25	U1, U2, U3	70	Apex, 3mm below CEJ, mid-root	0.28 - 4.21
dos Santos (2019) (23)	Portugal	18 - 73	U1, U2, U3	202	4mm below CEJ, mid-root	0.5 - 0.8
D'Silva (2019) (24)	USA	22 - 84	U1, U2, U3	66	4mm below CEJ, mid-root	0.48 - 1.1
El Nahass and Naiem (2014) (25)	Egypt	24 - 56	U1, U2	73	1, 2, 4mm below crest	0.57 - 0.84
Frost (2014)(thesis) (26)	USA	20 - 78	U1, U2, U3	56	1mm below crest	0.59 - 0.8
Frumkin and Klinger (2017) (27)	Israel	21 - 75	U1, U2	35	Apex, crestal level	1.12 - 1.93
Fuentes (2015) (28)	Chile	15 - 60	U1, U2, U3	50	Apex, mid-root	0.6 - 2.13
Gakonyo (2018) (29)	Kenya	18 - 81	U1, U2, U3	184	4mm below CEJ , mid-root	0.48 - 0.7
Ghassemian (2012) (30)	Italy	17 - 69	U1, U2, U3	66	1-5mm below crest	1.13 - 1.73
Gluckman (2017) (31)	South Africa	18 - 89	U1, U2, U3	150	Apex, 1mm below crest and middle of the two	0.5 - 1.5
Hacopian (2015) (dissertation) (32)	USA	NR	U1	26	3, 6, 9, 12mm below CEJ	1.05 - 1.9
Januário (2011) (33)	Brazil	17 - 66	U1, U2, U3	250	1, 3, 5mm below crest	0.5 - 0.7
Jin (2012) (34)	Korea	21.9 ± 3	U3	20	Apex, 3, 5mm below CEJ	1.3 - 4.5
Jung (2017) (35)	Korea	20 - 50	U1, U2	199	Apex, 2, 4, 6mm below crest	0.26 - 1.18
Kheur (2015) (36)	India	NR	U1	150	Apex, mid-root, 3mm below CEJ	0.89 - 1.57
Khoury (2016) (37)	Lebanon	21 - 48	U1, U2, U3	47	4, 6, 8, 10mm below CEJ	0.51 - 1.14
YJ. Kim (2016) (38)	Korea	20 - 65	U1, U2, U3	20	1-5mm below crest	0.66 - 0.98
Koç (2019) (39)	Turkey	19 - 60	U1, U2, U3	62	1, 2mm below crest	0.69 - 1.06
JE. Lee (2019) (40)	Korea	21.9 ± 3	U1, U2	20	Apex, 3, 5mm below CEJ	1.0 - 2.3
SL. Lee (2010) (41)	Korea	20 - 39	U1, U2, U3	20	3mm bellow CEJ, apex, mid-root	0.54 - 1.24
Lim (2019) (42)	Korea	20 - 48	U1, U2, U3	32	1, 3, 5mm below crest	0.5 - 1.3
Lin (2018) (43)	Taiwan	33 - 80	U1, U2, U3	21	3, 5mm below CEJ	0.42 - 1.16
López-Jarana (2018) (44)	Spain	NR	U3	49	4mm below crest, apex	1.04 - 2.19
Ma (2019) (45)	China	NR	U1, U2	62	2, 4, 6mm bellow CEJ, apex	0.4 - 1.92
Mallikarjun (2016) (46)	India	20 - 45	U1	10	1mm below crest	0.77 - 1.18
Morad (2014) (13)	Iran	NR	U1, U2, U3	352	1-5mm below crest	0.9 - 1.26
Nahás-Scocate (2014) (47)	Brazil	20 - 47	U1	30	Apex, midroot	0.68 - 1.23
Nowzari (2010) (48)	USA	15 - 82	U1	101	1-10 mm below crest	1.0 - 1.2
Pascual (2017) (49)	Spain	22 - 49	U1, U2, U3	15	4mm below CEJ, apex	0.78 - 3.94
Prakash (2019) (50)	India	NR	U1	50	Mid-root	0.58 - 0.82
Rojo-Sanchis (2019) (51)	Spain	18 - 60	U1, U2, U3	82	1, 2, 3mm below crest	0.47 - 1.08
Sendyk (2017) (52)	Brazil	26.6 ± 4.6	U1, U2, U3	70	3, 6, 8mm below CEJ	0.4 - 2.1

Shrestha (2019) (53)	China	19 - 82	U1, U2, U3	146	4mm below CEJ and mid-root	0.42 - 1.04
Tian (2015) (54)	China	18 - 30	U1	45	Apex, mid-root	0.13 - 2.69
Üner (2019) (55)	Turkey	21 - 53	U1	160	3, 6, 9mm below CEJ	1.06 - 1.18
Wang (2014) (56)	China	18 - 60	U1, U2, U3	300	4mm below CEJ, mid-root	0.5 - 0.9
Younes (2015) (57)	Belgium	18 - 65	U1, U2, U3	21	1, 2, 3, 5mm below crest	0.89 - 1.27
Zekry (2014) (58)	China	17 - 82	U1, U2, U3	200	1, 3, 5mm below crest	0.81 - 1.09
SC. Zhang (2015) (59)	China	20 - 48	U1, U2, U3	105	Apex, mid-root	0.61 - 0.95
CY. Zhang (2016) (60)	USA	NR	U1, U2	239	Mid-root	0.92 - 1.62
Zhou (2013) (61)	China	18 - 42	U1, U2, U3	80	3mm below CEJ, mid-root, apex	0.59 - 2.04

Abbreviations: U1, upper central incisor; U2, upper lateral incisor; U3, upper canine; NR, not reported.

Table 2. Risk of Bias Assessment of Studies

Refrences	Clear Objectives	Justified Sample Size	Selection Process	Measurement Validity	Measurement Reliability	Statistical Analysis	Description of Methods	Described Basic Data	Justified Discussion	Ethical Considerations
Alsaffar et al. (2016) (16)	Y	N	U	Y	Y	Y	Y	U	Y	Y
Amid et al. (2017) (15)	Y	N	U	Y	Y	Y	U	Y	Y	Y
Arief et al. (2013) (17)	Y	N	Y	Y	N	Y	Y	U	Y	N
Batista Jr et al. (2012) (18)	Y	N	U	Y	U	Y	Y	Y	Y	Y
Behnia et al. (2015) (14)	Y	N	Y	Y	Y	Y	U	Y	Y	Y
Braut et al. (2011) (19)	Y	N	U	Y	N	Y	Y	Y	Y	N
Cook et al. (2011) (20)	Y	Y	Y	Y	Y	Y	U	U	Y	Y
Demircan and Demircan (2015) (21)	Y	N	Y	Y	N	N	Y	Y	Y	Y
Ding et al. (2013) (22)	Y	N	U	Y	N	Y	Y	Y	Y	Y
dos Santos et al. (2019) (23)	Y	N	U	Y	Y	Y	Y	U	Y	Y
D'Silva et al. (2019) (24)	Y	Y	Y	Y	U	Y	U	Y	Y	Y
El Nahass and Naiem (2014) (25)	Y	N	Y	Y	N	Y	U	Y	Y	N
Frost (2014) (thesis)(26)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Frumkin and Klinger (2017)(27)	Y	N	U	Y	N	Y	U	Y	Y	Y
Fuentes et al. (2015)(28)	Y	N	Y	Y	U	Y	Y	Y	Y	Y
Gakonyo et al. (2018)(29)	Y	N	Y	Y	U	Y	U	Y	Y	Y
Ghassemian et al. (2012) (30)	Y	N	Y	Y	Y	Y	U	Y	Y	Y
Gluckman et al. (2017) (31)	Y	N	U	Y	Y	Y	Y	Y	Y	N
Hacopian (2015) (dissertation) (32)	Y	N	U	Y	Y	Y	N	Y	Y	N
Januário et al. (2011) (33)	Y	N	Y	Y	U	N	U	Y	Y	Y
Jin et al. (2012) (34)	Y	N	Y	Y	Y	Y	Y	Y	Y	Y
Jung et al. (2017) (35)	Y	N	Y	Y	U	Y	Y	Y	Y	Y
Kheur et al. (2015) (36)	Y	Y	Y	Y	U	Y	Y	U	Y	N
Khoury et al. (2016) (37)	Y	N	Y	Y	U	Y	U	Y	Y	Y
YJ. Kim et al. (2016) (38)	Y	N	Y	Y	U	Y	Y	Y	Y	Y
Koç et al. (2019) (39)	Y	N	Y	Y	Y	Y	U	Y	Y	N
JE. Lee et al. (2019) (40)	Y	N	Y	Y	N	Y	U	Y	Y	Y
SL. Lee (2010) (41)	Y	N	Y	Y	N	Y	Y	Y	Y	N
Lim et al. (2019) (42)	Y	N	Y	Y	Y	Y	Y	Y	Y	Y
Lin et al. (2018) (43)	Y	N	U	Y	Y	Y	U	Y	Y	N
López-Jarana et al. (2018) (44)	Y	N	U	Y	Y	Y	Y	Y	Y	Y
Ma et al. (2019) (45)	Y	Y	Y	Y	Y	Y	Y	U	Y	Y
Mallikarjun et al. (2016) (46)	Y	N	U	Y	N	Y	U	Y	Y	Y

Morad et al. (2014) (13)	Y	N	Y	Y	Y	Y	Y	Y	Y	N
Nahás-Scocate et al. (2014) (25)	Y	N	Y	Y	Y	Y	Y	Y	Y	Y
Nowzari et al. (2010) (48)	Y	N	Y	Y	Y	Y	Y	Y	Y	Y
Pascual et al. (2017) (49)	Y	N	Y	Y	Y	Y	N	Y	Y	Y
Prakash et al. (2019) (50)	Y	N	U	Y	U	N	Y	U	Y	Y
Rojo-Sanchis et al. (2019) (51)	Y	Y	U	Y	Y	Y	Y	Y	Y	Y
Sendyk et al. (2017) (52)	Y	Y	Y	Y	Y	Y	U	Y	Y	Y
Shrestha et al. (2019) (53)	Y	N	Y	Y	Y	Y	U	Y	Y	Y
Tian et al. (2015) (54)	Y	N	Y	Y	Y	Y	Y	U	Y	Y
Üner et al. (2019) (55)	Y	N	Y	Y	N	Y	Y	Y	Y	Y
Wang et al. (2014) (56)	Y	N	Y	Y	Y	Y	Y	Y	Y	Y
Younes et al. (2015) (57)	Y	N	Y	Y	Y	Y	Y	Y	Y	Y
Zekry et al. (2014) (58)	Y	N	Y	Y	Y	Y	Y	Y	Y	Y
SC. Zhang et al. (2015) (59)	Y	N	Y	Y	U	Y	Y	Y	Y	Y
CY. Zhang et al. (2016) (60)	Y	N	U	Y	Y	Y	U	U	Y	Y
Zhou et al. (2013) (61)	Y	N	Y	Y	Y	Y	Y	Y	Y	Y