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SYSTEMATIC REVIEW

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The correlation between dental caries and dermatoglyphics: a systematic review and meta-analysis

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Abstract

Here, we used a meta-analysis approach to systematically evaluate the correlation between dental caries and dermatoglyphics. To identify findings relating to the association between dental caries and dermatoglyphics, a methodical literature search was conducted in the PubMed, Embase, Cochrane Library, and Web of Science databases from inception to August 2023. Data analysis was performed using RevMan 5.3 and Stata 15.0 software, combining odds ratios (ORs) and 95% confidence intervals (CIs). A total of eight studies were included, comprising 1563 participants, with 883 in the dental caries group and 680 in the caries-free group. The distribution of arches, loops and whorls between the dental caries group and the caries-free group did not differ significantly. Except for an observed statistical significance in the distribution of arches by study type (p = 0.02), there were no significant differences between the other subgroups. The occurrence rate of whorls was higher in the dental caries group than in the healthy group among female participants, while the distribution of loops was less frequent. Current evidence shows that in the female population, caries and dermatoglyphics were associated, however, in the overall population, the distribution of arches, loops and whorls did not correlate significantly with dental caries, according to this meta-analysis.

Keywords

Dental caries; Dermatoglyphics; Meta-analysis

1. Introduction

The term “Dermatoglyphics” was introduced by Cummins at the 42nd Annual Meeting of the American Association of Anatomists in 1926 [1]. Dermatoglyphics represents the fusion of two Greek words, in which “derma” refers to skin and “glyphe” refers to carving, collectively representing carvings on the skin [2]. Dermatoglyphics refers to the study of patterns formed by raised ridges on the fingers, palms and soles and had extensive applications in the field of criminology [3]. Over the years, this method has served as a powerful tool for diagnosing psychosocial, medical and genetic conditions [4]. Several studies have indicated certain associations between dermatoglyphics and congenital defects, including Down’s syndrome [5], Alzheimer’s disease [6], multiple sclerosis [7], cleft lip and palate [8], periodontal disease [9], bruxism [10], malocclusion [11], and oral submucous fibrosis [12].

Dental caries, one of the most prevalent oral diseases, has been recognized by the World Health Organization as one of the three major chronic and non-communicable diseases alongside cancer and cardiovascular diseases [13]. Dental caries refers to the chronic progressive destruction of the hard tissues of the tooth primarily influenced by bacterial factors [14]. The complex interplay of genetic, biochemical, anatomical, social and behavioral, dietary, and oral hygiene practices is thought to lead to the development of dental caries [15, 16]. Dental caries poses significant harm but is also associated with the availability of effective preventive measures, minimal pain during early treatment, minimal damage and a low financial burden [14]. Therefore, the prevention of dental caries is of paramount importance. Furthermore, the prediction of caries plays a crucial role in identifying susceptible individuals and improving preventive efficiency.

Fingerprints are highly stable, and the fundamental properties of fingerprints remain the same from birth to death [17]. Both the enamel and finger buds epithelium are derived from the ectoderm and develop simultaneously [18]. Maternal environmental factors during pregnancy can affect fetal tooth development. Factors such as viruses, drugs, environmental pollution, and X-ray exposure during early pregnancy can also affect tooth development, resulting in abnormalities in the enamel or dentin structure [19]. Dermatoglyphic polymorphisms are the result of a combination of genetic and environmental factors in the early stages of an individual’s development. Factors such as intrauterine viral infections, radiation, alcohol and drugs taken by pregnant women can radically interfere with the formation of dermatoglyphics [20]. Due to similarities in the environmental and genetic factors

affecting the development of teeth and dermal patterns, it is reasonable to hypothesize that there is a correlation between dermatoglyphics and dental caries. Susceptibility to caries caused by genetic factors such as enamel structural abnormalities, tooth morphology, and eruption can be reflected by dermatoglyphic patterns [21]. In a previous study, Somani *et al*. [22] found that the distribution of arch patterns was more common in a healthy group without caries. Eswara Uma *et al*. [2] further reported that as the prevalence of loop patterns increases in preschool children, individual susceptibility to dental caries decreases, while a significant increase in arch patterns on the left thumb was linked to a higher incidence of caries.

However, the conclusions derived from previous studies have been inconsistent. Most studies have concluded that the susceptibility to caries increases with increasing whorl patterns and decreases with increasing loop patterns [3, 23, 24]. However, some studies have reached the opposite conclusion [25, 26]. To prove this correlation and to provide evidence for the prevention of caries, this investigation set out to comprehensively evaluate the association between dental caries and dermatoglyphics. Our analysis showed that by recognizing the type and number of fingerprints, it is possible to identify children who are prone to caries, screen them early and take appropriate preventive measures.

2. Materials and methods

2.1 Literature search strategy

Following the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analysis) 2020 declaration [27], this systematic analysis was completed and subsequently recorded in PROSPERO (Reference: CRD42023431240). When preparing this research, we followed the PRISMA guidelines and completed the PRISMA checklist, details of which can be found in **Supplementary Table 1** and **Supplementary Table 2**. We performed a comprehensive search of the existing literature by screening the PubMed, Embase, Cochrane Library, and Web of Science databases from inception to August 2023 to identify papers evaluating the relationship between dental caries and dermatoglyphics. All studies were conducted in English. The following terms were used to screen the databases: "dental caries" and "dermatoglyphics". Detailed search strategies are shown in **Supplementary Table 3**. In this search, we used a combination of MeSH terms and their free forms. In addition, the reference list of each of the included articles was checked thoroughly. Two reviewers independently conducted the search and assessment of the included studies. Consensus was used to settle any disagreements discovered throughout the literature search.

2.2 Identification of eligible studies

Studies were considered for inclusion if they met the following criteria:

(1) Cross-sectional or case-control study design;

(2) Literature investigating the correlation between dermatoglyphics and dental caries;

(3) Similar experimental designs and methods among the studies, with a complete set of data reported;

(4) Full-text articles published in English;

(5) The provision of sufficient data or convertible data to calculate odds ratios (ORs);

(6) The assessment of at least one outcome (fingerprint types such as arches, loops and whorls);

(7) The diagnosis of dental caries was based on decayed, missing and filled teeth (DMFT), following the criteria proposed by the World Health Organization.

Studies were excluded if they met any of the following criteria:

(1) Reviews, letters, editorial comments, case reports, conference abstracts, animal studies, unpublished articles, and non-English articles;

(2) Studies without a control group or lacking essential information relating to the cases;

(3) Duplicate publications and studies with incomplete or unusable data;

(4) Case groups with a history of chronic diseases such as diabetes in addition to dental caries.

2.3 Data extraction

Two researchers worked independently to retrieve the data. A third investigator settled any discrepancies to achieve a final verdict. The first author, publication year, country of research, study design, sample size, age, gender, number of arch patterns, number of loop patterns, and number of whorl patterns were extracted from the included studies for analysis. We contacted the relevant authors when data was missing or not reported to acquire a comprehensive dataset, if available.

2.4 Quality assessment

For cross-sectional studies, quality assessment was performed by two researchers using the Agency for Healthcare Research and Quality (AHRQ) scale, which has a total score of 11. Scores between 8 and 11 indicate high quality, scores between 4 and 7 indicate moderate quality, and scores below 4 indicate low quality [28]. Case-control studies were assessed for quality using the Newcastle-Ottawa Scale (NOS) [29], which has a total score of 9. Scores ranging from 7 to 9 indicate good quality, while scores ranging from 4 to 6 suggest intermediate quality.

2.5 Statistical analysis

We used Review Manager (RevMan) 5.3 version (Cochrane Collaboration, London, UK) and Stata 15.0 version (Stata Corp, College Station, TX, USA) to record and analyze the study data. To analyze heterogeneity, we used the Chi-squared (χ^2) test (Cochran's Q) and the inconsistency index (I^2). Significant heterogeneity was defined as a p value < 0.05 (for χ^2) or $I^2 > 50\%$. In such cases, a random-effect model was used to generate the combined odds ratios (ORs) and 95% confidence intervals (CIs); otherwise, a fixed-effect model was applied. In some cases, subgroup analysis was used to investigate the origins of heterogeneity. By successively omitting individual studies, sensitivity analysis was carried out to determine how

specific exclusions might affect the overall risk assessment.

3. Results

3.1 Literature search and study characteristics

Fig. 1 shows a flowchart describing the process used for the literature search and article selection. Systematic literature searches in PubMed (n = 158), Embase (n = 82), Cochrane Library (n = 3), and the Web of Science (n = 262) yielded a total of 505 pertinent articles; 294 titles and abstracts were assessed after duplicate papers were removed. Finally, eight full-text publications were considered in the final analysis [26, 30–36].

Table 1 summarizes the key characteristics of the selected studies. Of the eight studies, two were case-control studies [33, 34], and six were cross-sectional studies [26, 30–32, 35, 36]. A total of 1563 participants were included; 883 patients with dental caries and 680 without dental caries. Two case-control studies were of high quality, while the quality of the other cross-sectional studies was moderate.

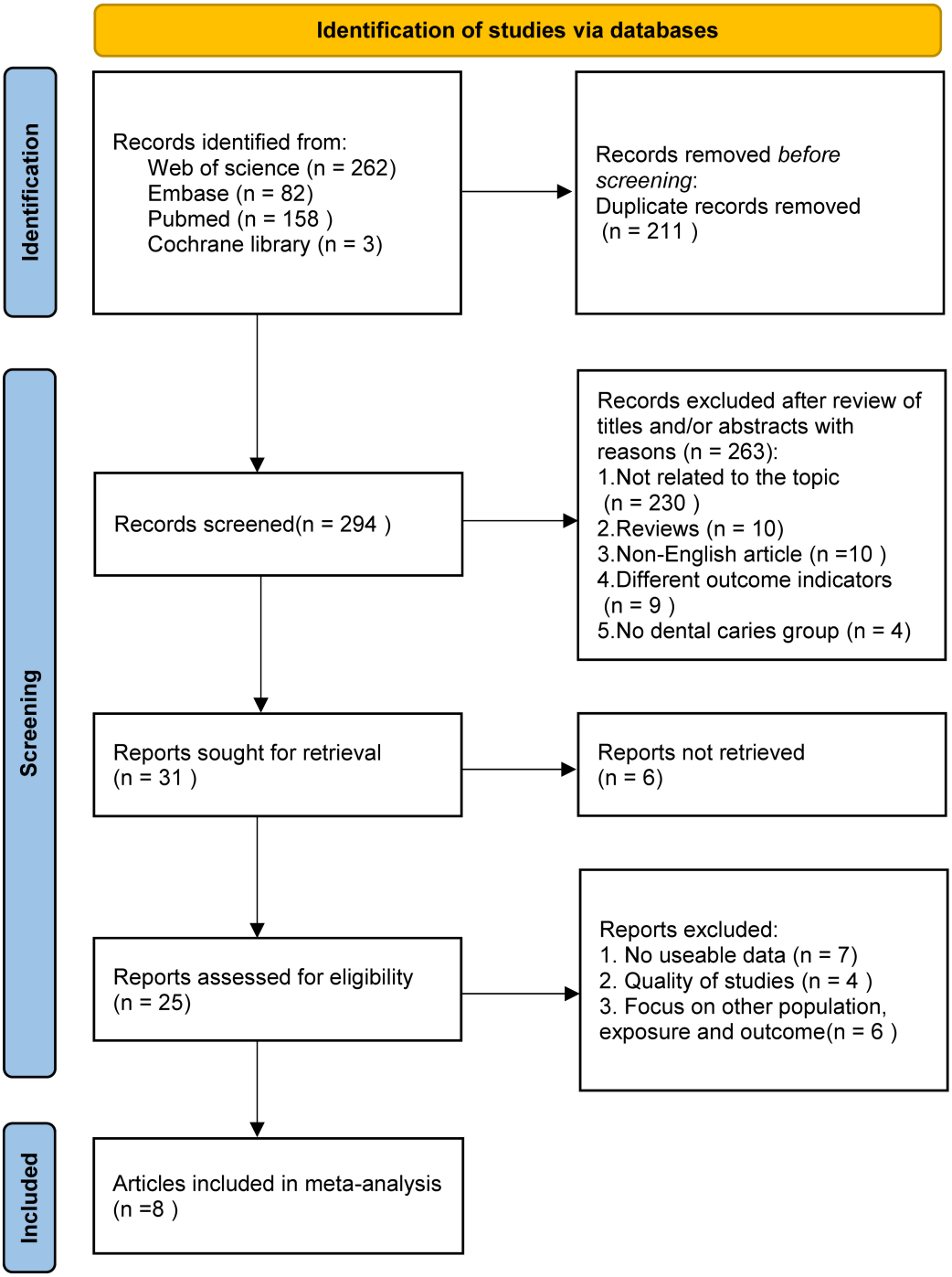

FIGURE 1. PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analysis) flowchart for the systematic search and selection process. A total of 8 studies that satisfied the eligibility criteria were included in this systematic review.

TABLE 1. Baseline characteristics of the included studies and methodological assessment.

Study	Country	Study Design	Age	Sample	Gender	Whorl Number Cases/Controls	Loop Number Cases/Controls	Arch Number Cases/Controls	Quality score
Sengupt *et al.* [30], 2013	India	cross-sectional study	4–14	caries group = 200, control group = 100	Both	44/41	63/52	3/7	6
Asif *et al.* [31], 2017	India	cross-sectional study	5–12	caries group = 200, control group = 200	Both	766/391	776/984	458/625	6
Agarwal *et al.* [26], 2018	India	cross-sectional study	3–7	caries group = 50, control group = 50	Both	16/19	26/18	8/13	4
Singh *et al.* [33], 2020	India	case-control study	—	caries group = 125, control group = 125	Both	65/48	81/97	37/15	8
Devi *et al.* [32], 2020	India	cross-sectional study	5–12	caries group = 10, control group = 10	Both	1/7	8/1	1/2	4
Mokhtari *et al.* [34], 2021	Iran	case-control study	3–6	caries group = 101, control group = 86	Both	31/28	43/35	27/23	8
Lingam *et al.* [36], 2022	Saudi Arabia	cross-sectional study	15–30	caries group = 119, control group = 31	Both	91/1	15/12	13/18	6
Kattakayam *et al.* [35], 2022	India	cross-sectional study	3–5	caries group = 78, control group = 78	Both	607/180	173/600	—	5

3.2 Meta-analysis results

Eight studies analyzing the association between dental caries and whorl and loop patterns were included [26, 30–36]. The pooled result revealed significant heterogeneity among the studies ($p < 0.05$, $I^2 = 97\%$). There was no significant difference in whorl patterns between individuals with dental caries and healthy individuals (OR = 2.09, 95% CI (0.96, 4.53), $p = 0.06$) (Fig. 2A). These findings revealed no statistically significant relationship between dental caries and loop patterns (OR = 0.71, 95% CI (0.31, 1.62), $p = 0.42$) (Fig. 2B).

Seven articles observed the ORs when comparing dental caries to healthy individuals in terms of arch patterns [26, 30–34, 36]. Heterogeneity testing showed that $I^2 = 86\%$ and $p < 0.05$, thus indicating heterogeneity between the two studies. Therefore, the effect sizes were combined using a random-effect model; analysis found no statistically significant difference between the arch patterns of the two categories (OR = 0.56, 95% CI (0.28, 1.12), $p = 0.10$) (Fig. 2C).

Since these studies included both males and females, we conducted separate meta-analyses for males and females. Four studies reported the relationship between dental caries and whorl patterns in males [30, 31, 33, 35]. We performed analysis using a random effects model ($I^2 = 95\%$, $p < 0.05$). We found no significant correlation between male dental caries patients and whorl patterns (OR = 3.40, 95% CI (0.95, 12.10), $p = 0.06$) (Fig. 3A).

Four studies analyzed the relationship between dental caries and loop patterns in males [30, 31, 33, 35]. Pooled analysis found no significant correlation between dental caries in males and loop patterns (OR = 0.45, 95% CI (0.17, 1.19), $p = 0.11$); however, there was significant heterogeneity ($I^2 = 93\%$, $p < 0.05$) (Fig. 3B).

Three studies analyzed arch patterns in males with dental caries [30, 31, 33]. Our meta-analysis found no significant correlation between dental caries in males and arch patterns (OR = 1.00, 95% CI (0.28, 3.55), $p = 1.00$), although there was statistically significant heterogeneity ($I^2 = 77\%$, $p = 0.01$) (Fig. 3C).

Four studies provided data relating to whorl patterns in females with dental caries [30, 31, 33, 35]. Analysis showed a significantly higher occurrence of whorl patterns in females with dental caries when compared to healthy females (OR = 3.50, 95% CI (1.54, 7.98), $p = 0.003$), with substantial heterogeneity ($I^2 = 87\%$, $p < 0.05$) (Fig. 4A).

Four articles were included in our analysis of dental caries and loop patterns in females [30, 31, 33, 35]. Overall, the data showed considerable heterogeneity ($I^2 = 85\%$, $p < 0.05$) and revealed a significantly lower frequency of loop patterns in females with dental caries when compared to those without dental caries (OR = 0.39, 95% CI (0.20, 0.76), $p = 0.006$) (Fig. 4B).

Three articles were included in our analysis of arch patterns in females with dental caries [30, 31, 33]. This analysis involved a random effect model ($I^2 = 84\%$, $p < 0.05$); we found no statistically significant association between female dental caries patients and arch patterns (OR = 1.15, 95% CI (0.33, 4.00), $p = 0.82$) (Fig. 4C).

3.3 Subgroup meta-analysis

Due to the notable heterogeneity between the chosen studies, we next carried out subgroup analyses, considering factors including study region (India and non-India), study design (cross-sectional and case-control), age (3–7 years and not-3–7 years), sample size (≥200 and <200), and quality score (>5 and ≤5).

The distribution of whorl patterns and loop patterns were not significantly different when compared between the case group and the control group, or between the Indian and non-Indian populations ($p > 0.05$). There was no significant difference between the case-control and cross-sectional studies ($p > 0.05$). In case-control studies, there was a reduction in heterogeneity although this remained significant. There were no significant differences in terms of the distribution of whorl patterns and loop patterns distribution when compared between age subgroups (3–7 years and not-3–7 years) or between individuals with dental caries and healthy individuals in either group ($p > 0.05$). Based on sample size, there was no statistically noteworthy variation in whorl and loop pattern distribution across subgroups ($p > 0.05$). In studies with a sample size ≥200, the distribution of whorl patterns in the dental caries group was significantly higher than that in the non-caries group ($p < 0.05$). The distribution of loop patterns was significantly reduced in the dental caries group when compared to the non-caries group in studies with a sample size of 200 ($p < 0.05$); furthermore, heterogeneity was significantly reduced ($I^2 = 18\%$). There was no significant difference between the quality rating subgroups, in terms of the distribution of whorl patterns and loop patterns ($p > 0.05$). However, among studies with a rating higher than 5 points, there was a significant association between the presence of dental caries and a higher prevalence of whorl patterns and a lower prevalence of loop patterns ($p = 0.02$) (Tables 2,3).

There was no statistically significant difference in the distribution of arch patterns when compared between the Indian and non-Indian regions ($p > 0.05$), and there was no statistical difference in the distribution of arch patterns between the dental caries patients and the healthy individuals in both groups. Study type had a statistically significant influence on the correlation between dental caries and arch patterns ($p = 0.02$). When considering cross-sectional studies, there was a statistically significant difference between the arch patterns of the dental caries group and the normal population ($p = 0.01$). Furthermore, we found that age distribution did not exert a significant effect on the meta-analysis results ($p > 0.05$). The occurrence rate of arch patterns was significantly lower in patients with dental caries who were not in the 3–7 years age group when compared to healthy individuals ($p = 0.03$), and heterogeneity was reduced significantly ($I^2 = 3\%$) in the 3–7 years age group. There was no significant difference in the distribution of arch patterns across subgroups (based on sample size) and the distribution of arch patterns between dental caries patients and healthy persons in the two groups ($p > 0.05$). Furthermore, meta-analysis showed that there was no significant difference between subgroups with different quality scores ($p > 0.05$), and that the level of heterogeneity in the subgroup with a score ≤5 was reduced ($I^2 = 0\%$) (Table 4).

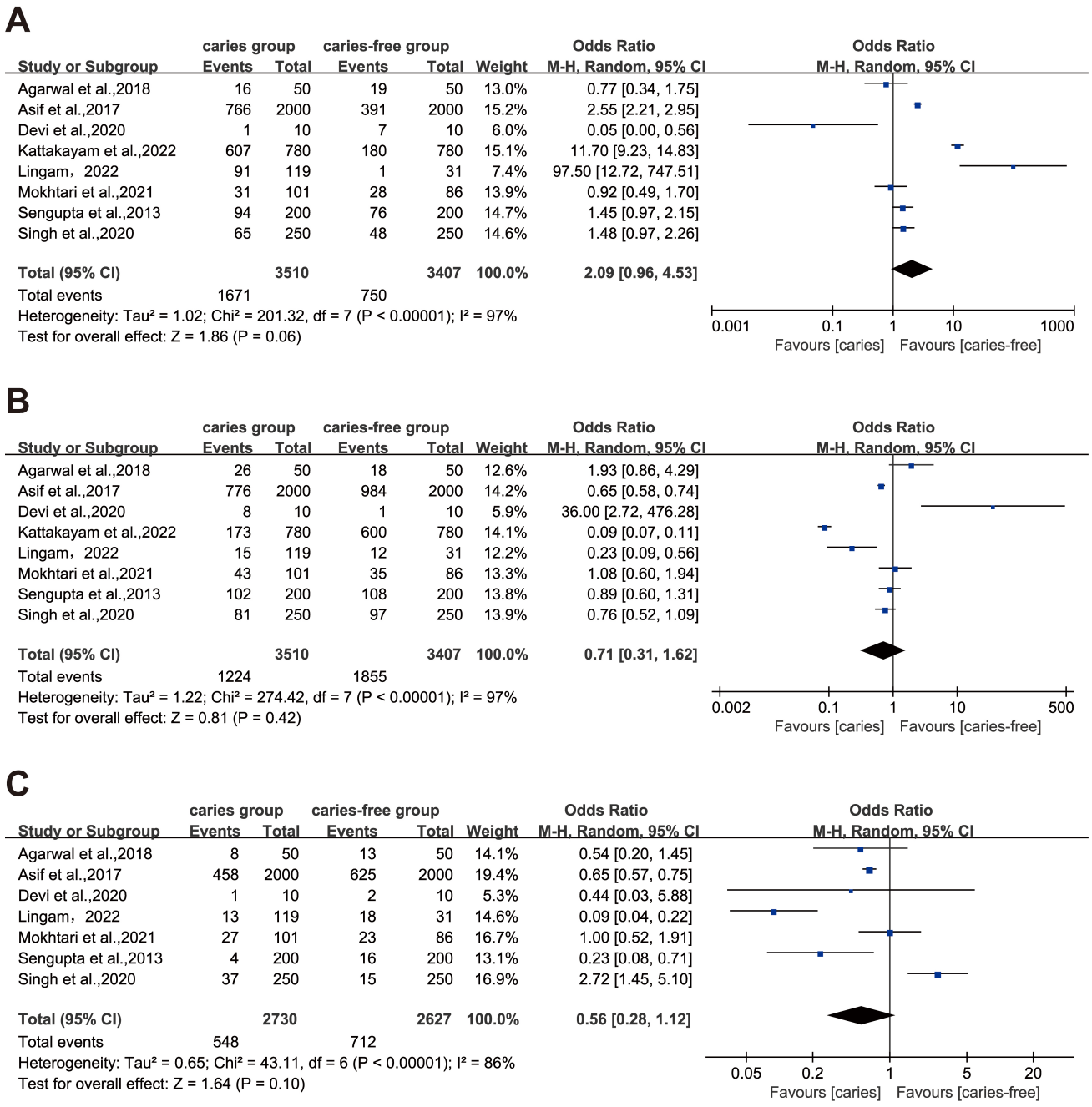

FIGURE 2. Forest plots of fingerprint patterns in the caries group and caries-free group. (A) whorl patterns, (B) loop patterns, and (C) arch patterns. Three Forest plots were generated based on the random-effects model. CI: confidence interval.

3.4 Sensitivity analysis

Sensitivity analysis was conducted by sequentially excluding individual studies. When any particular trial was eliminated, analysis showed that loop patterns did not affect the final results, thus illustrating that our results were very stable (Fig. 5A). Arch patterns were reduced in the estimate yielded by the random effect model after excluding Singh *et al.* [33], 2020, thus suggesting that this particular study may represent a source of heterogeneity (Fig. 5B). Whorl patterns were increased in the effect size after excluding Agarwal *et al.* [26], 2018, Devi *et al.* [32], 2020, and Mokhtari *et al.* [34], 2021, thus indicating that these three studies could represent potential sources of heterogeneity (Fig. 5C).

Sensitivity analysis of all male studies revealed that the exclusion of Sengupta *et al.* [30], 2013 increased the effect size of whorl patterns (Fig. 6A) and slightly reduced the effect size of loop patterns (Fig. 6B), thus suggesting that this study could represent a potential source of heterogeneity. The effect size of arch patterns remained unchanged; however, the exclusion of Asif *et al.* [31], 2017 eliminated heterogeneity (I^2 = 0%), thus accounting for the majority of the observed heterogeneity (Fig. 6C).

Sensitivity analysis of all female studies indicated relatively stable results for whorl (Fig. 7A) and arch patterns (Fig. 7B). The exclusion of Kattakayam *et al.* [35], 2022 significantly reduced heterogeneity (I^2 = 21%) for loop patterns, but caused no change in the effect size (Fig. 7C).

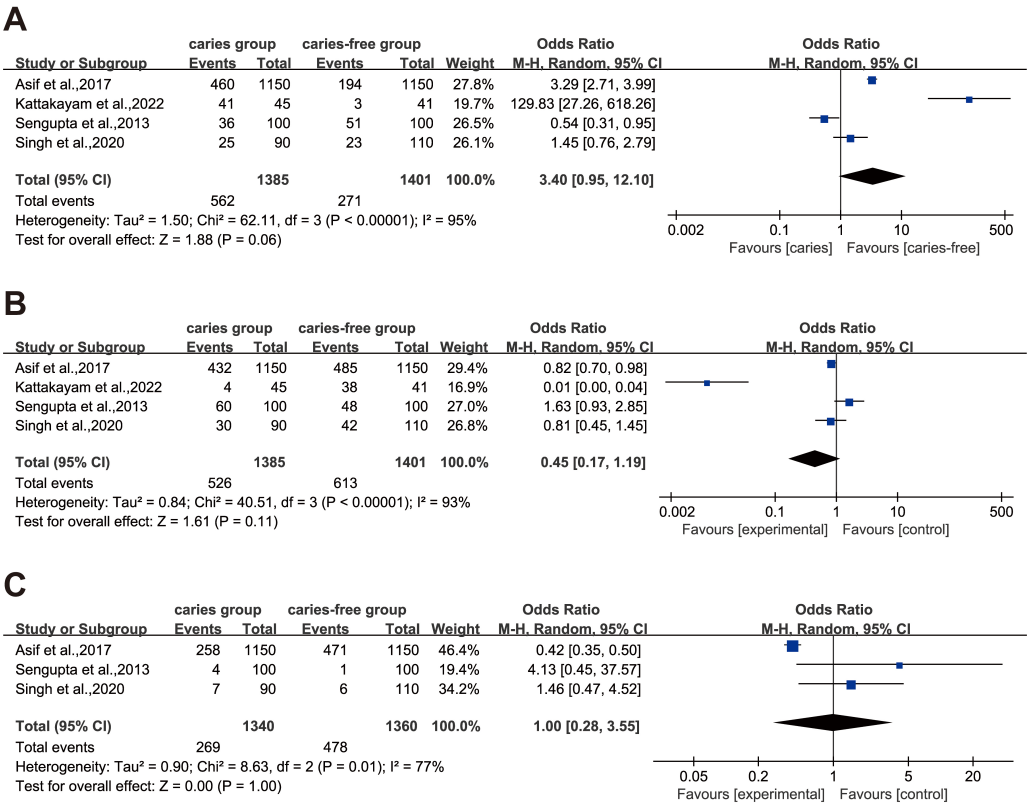

FIGURE 3. Forest plots of fingerprint patterns in the male caries group and the caries-free group. (A) whorl patterns, (B) loop patterns, and (C) arch patterns. Three Forest plots were generated based on the random-effects model. CI: confidence interval.

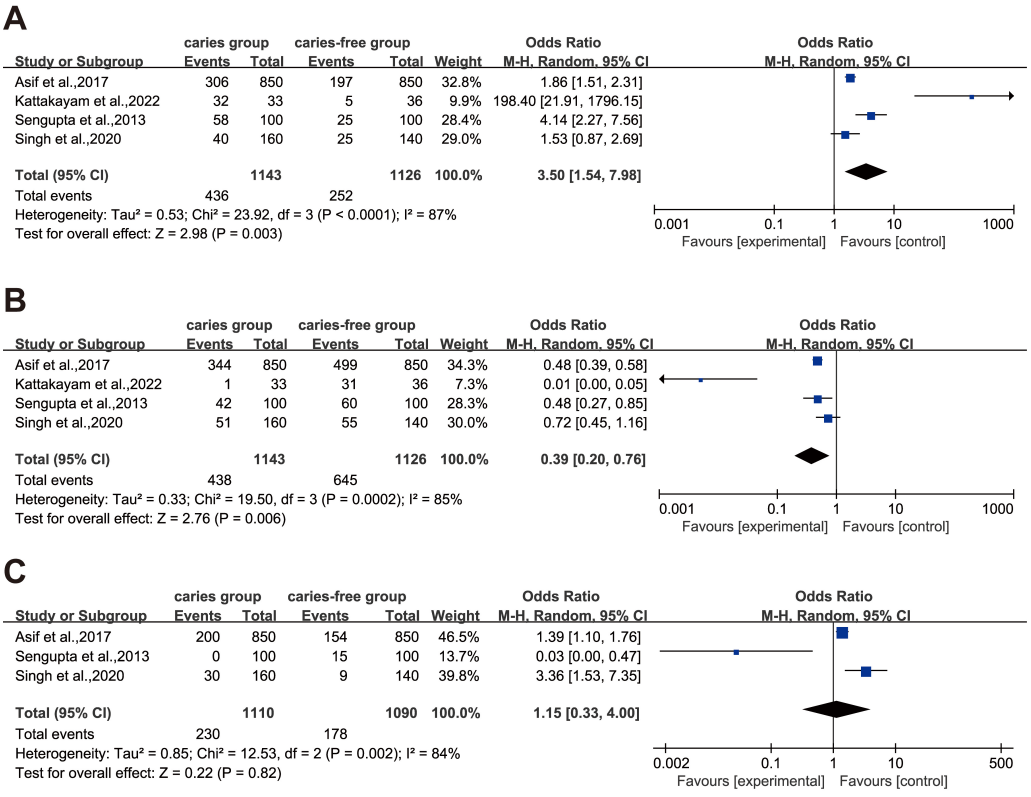

FIGURE 4. Forest plots of fingerprint patterns in the female caries group and the caries-free group. (A) whorl patterns, (B) loop patterns, and (C) arch patterns. Three Forest plots were generated based on the random-effects model. CI: confidence interval.

TABLE 2. The results of subgroup analysis relating to whorl patterns.

Subgroup	Studies	Heterogeneity		Effect model	OR	95% CI	*p*
		I^2	*p*				
Country [26, 30–36]	8	97%	<0.00001	Random	2.09	(0.96, 4.53)	0.06
India [26, 30–33, 35]	6	97%	<0.00001		1.70	(0.72, 3.98)	0.23
Non-India [34, 36]	2	96%	<0.00001		8.70	(0.05, 1445.34)	0.41
Study Design [26, 30–36]	8	97%	<0.00001	Random	2.09	(0.96, 4.53)	0.06
Cross-sectional study [26, 30–32, 35, 36]	6	97%	<0.00001		2.62	(1.00, 6.84)	0.05
Case-control study [33, 34]	2	36%	0.21		1.23	(0.78, 1.94)	0.37
Age [26, 30–32, 34–36]	7	97%	<0.00001	Random	2.21	(0.92, 5.31)	0.08
Age range 3–7 [26, 34, 35]	3	98%	<0.00001		2.07	(0.27, 16.01)	0.49
Age range not 3–7 [30–32, 36]	4	90%	<0.00001		2.25	(0.88, 5.73)	0.09
Sample [26, 30–36]	8	97%	<0.00001	Random	2.09	(0.96, 4.53)	0.06
Sample size ≥200 [30, 31, 33]	3	83%	0.003		1.82	(1.18, 2.83)	0.007
Sample size <200 [26, 32, 34–36]	5	96%	<0.00001		2.23	(0.38, 13.15)	0.37
Quality score [26, 30–36]	8	97%	<0.00001	Random	2.09	(0.96, 4.53)	0.06
Score >5 [30, 31, 33, 34, 36]	5	88%	<0.00001		1.98	(1.13, 3.47)	0.02
Score ≤5 [26, 32, 35]	3	97%	<0.00001		0.97	(0.07, 13.01)	0.98

CI: confidence interval; OR: odds ratio.

TABLE 3. The results of subgroup analysis relating to loop patterns.

Subgroup	Studies	Heterogeneity		Effect model	OR	95% CI	*p*
		I^2	*p*				
Country [26, 30–36]	8	97%	<0.00001	Random	0.71	(0.31, 1.62)	0.42
India [26, 30–33, 35]	6	98%	<0.00001		0.81	(0.30, 2.17)	0.67
Non-India [34, 36]	2	88%	0.005		0.52	(0.11, 2.37)	0.40
Study Design [26, 30–36]	8	97%	<0.00001	Random	0.71	(0.31, 1.62)	0.42
Cross-sectional study [26, 30–32, 35, 36]	6	98%	<0.00001		0.68	(0.23, 2.01)	0.49
Case-control study [33, 34]	2	3%	0.31		0.84	(0.61, 1.15)	0.28
Age [26, 30–32, 34–36]	7	98%	<0.00001	Random	0.73	(0.28, 1.89)	0.51
Age range 3–7 [26, 34, 35]	3	98%	<0.00001		0.55	(0.06, 4.75)	0.59
Age range not 3–7 [30–32, 36]	4	82%	0.0008		0.71	(0.38, 1.31)	0.27
Sample [26, 30–36]	8	97%	<0.00001	Random	0.71	(0.31, 1.62)	0.42
Sample size ≥200 [30, 31, 33]	3	18%	0.3		0.70	(0.60, 0.81)	<0.00001
Sample size <200 [26, 32, 34–36]	5	97%	<0.00001		0.83	(0.16, 4.35)	0.83
Quality score [26, 30–36]	8	97%	<0.00001	Random	0.71	(0.31, 1.62)	0.42
Score >5 [30, 31, 33, 34, 36]	5	62%	0.03		0.71	(0.54, 0.94)	0.02
Score ≤5 [26, 32, 35]	3	97%	<0.00001		1.42	(0.08, 25.70)	0.81

CI: confidence interval; OR: odds ratio.

TABLE 4. Results of subgroup analysis for arch patterns.

Subgroup	Studies	Heterogeneity		Effect model	OR	95% CI	*p*
		I^2	*p*				
Country [26, 30–34, 36]	7	86%	<0.00001	Random	0.56	(0.28, 1.12)	0.10
India [26, 30–33]	5	82%	<0.00001		0.72	(0.32, 1.61)	0.42
Non-India [34, 36]	2	94%	<0.00001		0.30	(0.03, 3.28)	0.33
Study Design [26, 30–34, 36]	7	86%	<0.00001	Random	0.56	(0.28, 1.12)	0.10
Cross-sectional study [26, 30–32, 36]	5	81%	0.0003		0.32	(0.13, 0.78)	0.01
Case-control study [33, 34]	2	79%	0.03		1.66	(0.62, 4.42)	0.31
Age [26, 30–32, 34, 36]	6	78%	0.0003	Random	0.41	(0.21, 0.80)	0.009
Age range 3–7 [26, 34]	2	3%	0.31		0.83	(0.48, 1.44)	0.50
Age range not 3–7 [30–32, 36]	4	86%	0.0001		0.27	(0.08, 0.90)	0.03
Sample [26, 30–34, 36]	7	86%	<0.00001	Random	0.56	(0.28, 1.12)	0.10
Sample size ≥200 [30, 31, 33]	3	91%	<0.00001		0.80	(0.26, 2.44)	0.70
Sample size <200 [26, 32, 34, 36]	4	83%	0.0004		0.38	(0.11, 1.37)	0.14
Quality score [26, 30–34, 36]	7	86%	<0.00001	Random	0.56	(0.28, 1.12)	0.10
Score >5 [30, 31, 33, 34, 36]	5	91%	<0.00001		0.56	(0.24, 1.31)	0.18
Score ≤5 [26, 32]	2	0%	0.89		0.53	(0.21, 1.33)	0.17

CI: confidence interval; OR: odds ratio.

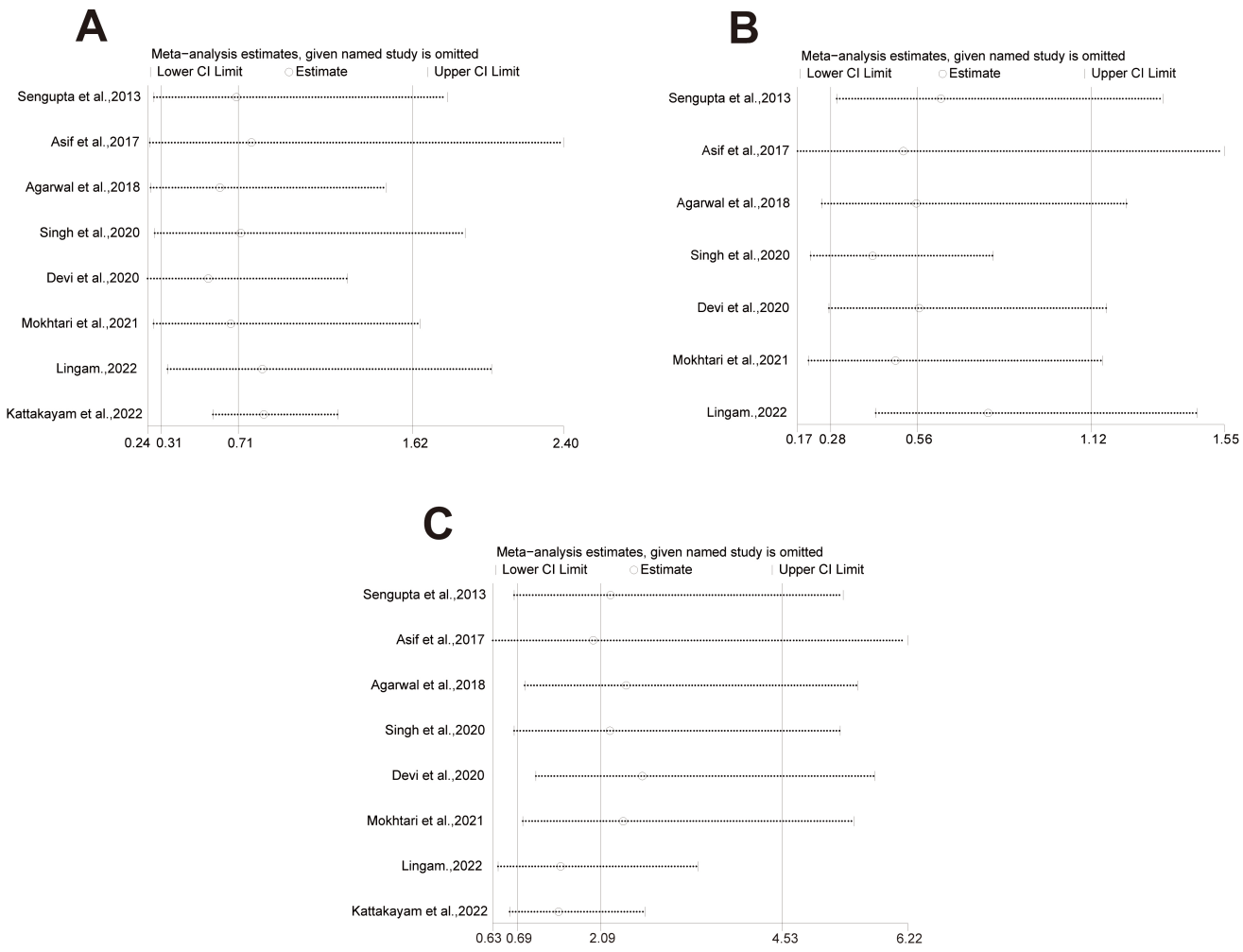

FIGURE 5. Sensitivity analysis of all studies. (A) loop patterns, (B) arch patterns, and (C) whorl patterns. Analysis was undertaken by eliminating individual studies one by one. CI: confidence interval.

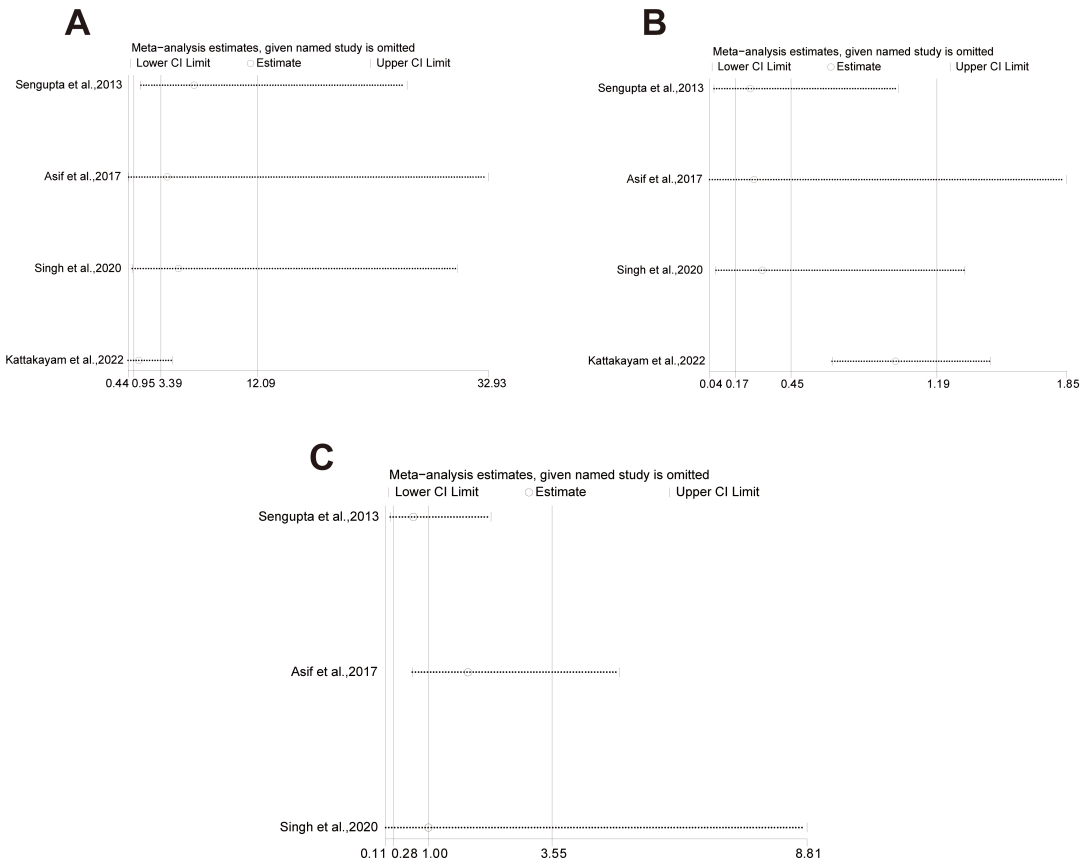

FIGURE 6. Sensitivity analysis of male studies. (A) whorl patterns, (B) loop patterns, and (C) arch patterns. Analysis was undertaken by eliminating individual studies one by one. CI: confidence interval.

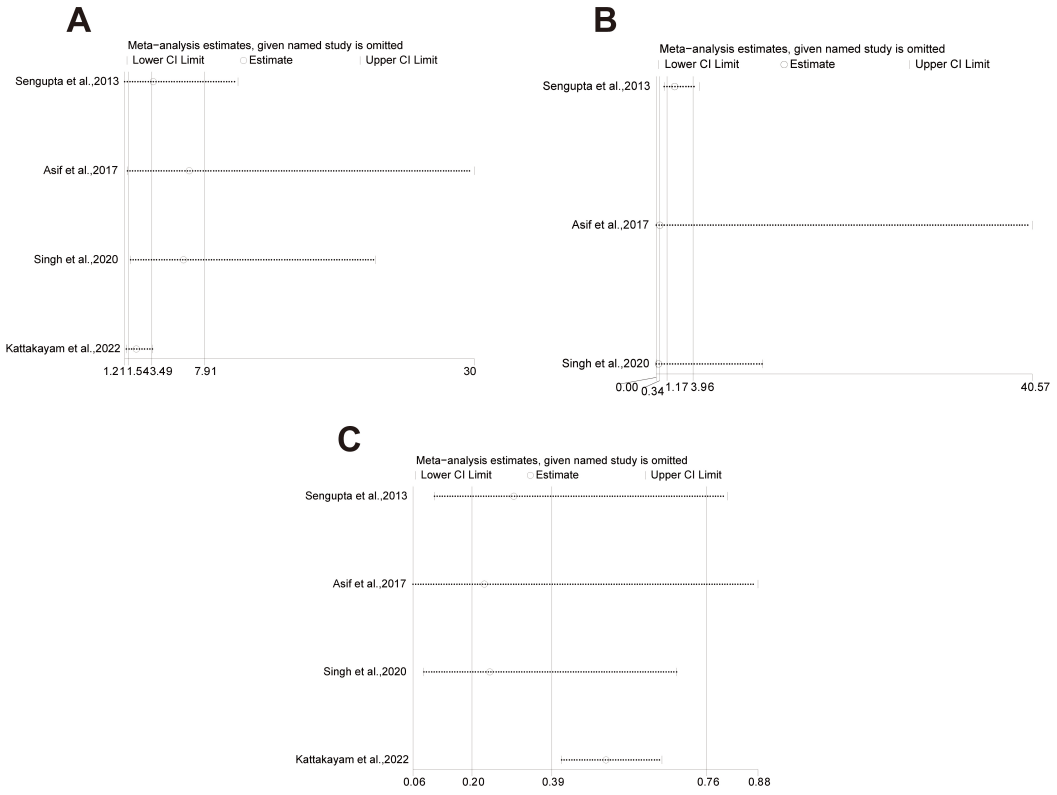

FIGURE 7. Sensitivity analysis of female studies. (A) whorl patterns, (B) arch patterns, and (C) loop patterns. Analysis was undertaken by eliminating individual studies one by one. CI: confidence interval.

3.5 Publication bias

Finally, since the number of included studies in our analysis was <10, publication bias was not assessed.

4. Discussion

The formation of dermal ridges begins in the 12th week of intrauterine life and is largely completed by the 24th week [2], thus coinciding with the timing of tooth development in intrauterine life [37]. This suggests that both normal and abnormal genetic information in the genome is decoded during this stage and can be replicated by dermatoglyphics [22, 38]. The ectoderm is essential for tooth formation and is the source of both the finger bud epithelium and the enamel, which develop simultaneously during intrauterine life [25, 39]. Abnormal genetic and environmental factors may affect the arrangement of dermal elevations during critical periods of fetal development, thus resulting in alterations in the dermatoglyphic conformation [20]. The risk of caries may be influenced by a number of genes, and the risk of developing dental caries is also associated with genetic polymorphisms [40]. Early life (from the zygote until the age of 8 years) is the phase most sensitive to exposure to environmental factors and is also a critical period for enamel development in both the primary and permanent teeth. During this period, exposure to environmental factors often results in varying degrees of defects in enamel development [41]. Therefore, an increased susceptibility to dental caries due to structural abnormalities in the teeth may be reflected by dermatoglyphics as environmental factors change throughout fetal life [42]. Once formed, dermatoglyphs persist and remain stable throughout the life cycle [43]. Environmental factors, such as improper bottle feeding after birth, excessive sugar intake, and the lack of brushing habits, are notable triggers of dental caries in young children [44]. Since caries is the result of a complex interaction of genetic and detect a specific correlation between caries and dermatoglyphics. In this context, our systematic review and meta-analysis of eight investigations revealed several important findings.

According to our results, there were no significant differences in the distribution of whorl, loop and arch patterns between individuals with dental caries and healthy individuals. Previous studies mostly reported that susceptibility to dental caries increases with an increase in whorl patterns [3, 23, 24, 45–48] and decreases with an increase in loop patterns [23, 24, 49, 50]; in contrast, individuals without caries have a higher number of arch patterns [3, 21, 51, 52]. Another study reported that arch patterns were highly positively correlated with relative enamel thickness (RET) and the greater the number of arch patterns, the greater the RET; these authors also found that RET was significantly negatively correlated with DMFT [53]. Fingerprint ridges are epithelial structures patterned by a Turing reaction-diffusion system based on signaling between the wingless/integrated (WNT) and antagonistic bone morphogenic protein (BMP) pathways. Primary ridges define the choice of arch, loop or whorl patterns. The mechanisms governing primary ridge patterning and morphogenesis are triggered by a Turing reaction-diffusion system [54]. Multiple signaling pathways are critical throughout tooth development, including BMP and WNT. BMP signaling influences the development of ameloblasts and plays a key role in the development of odontoblasts [55]. The WNT signaling pathway is known to regulate the onset and progression of dental caries [56]. Because both WNT and BMP play important roles in caries and fingerprint formation, it is reasonable to speculate that the association of caries and different fingerprint patterns is influenced by these signaling pathways. Although these pooled results did not reach statistical significance, the risk values for these three fingerprint types are consistent with conclusions from previous research. We also found that, compared to healthy individuals, female dental caries patients had a higher occurrence of whorl patterns and a lower distribution of loop patterns. This may be due to gender difference in caries; some studies have reported a significantly higher prevalence of caries in females than in males [57]. Another hypothesis is that perhaps the etiology of males with caries involves environmental factors rather than genetic susceptibility.

In our subgroup analysis of whorl patterns, we found that the heterogeneity of case-control studies in this group was reduced (I^2 = 36%); this may be related to the higher quality scores of the literature in the case-control group. Subgroups with sample sizes ≥200 and quality scores >5 indicated a higher distribution of whorl patterns among the dental caries group compared to the group without caries, thus suggesting that sample size and quality score can exert notable influence on the results. In the subgroup analysis of loop patterns, significant reductions in heterogeneity were observed for case-control studies and studies with sample sizes ≥200 (I^2 = 3%, I^2 = 18%), thus indicating that larger sample sizes and a case-control study design might mitigate some forms of selection bias and reduce heterogeneity. Among studies with sample sizes ≥200 and quality scores >5, individuals with caries had a lower presence of loop patterns when compared to those without caries. In our subgroup analysis of arch patterns, the dental caries group had fewer arch patterns than the normal group in cross-sectional studies and studies with an age outside the range of 3–7 years, thus suggesting that study type and age might contribute to inconsistencies in the results and main findings. Heterogeneity was reduced in the 3–7 years age range and studies with quality scores ≤5 (I^2 = 3%, I^2 = 0%), thus indicating that lower quality studies and studies with smaller age ranges may influence the association between dental caries and arch patterns.

Sensitivity analysis identified the research performed by Singh *et al.* [33], 2020 as a source of heterogeneity in the relationship between arch patterns and dental caries, and its omission affected our conclusion in that there was no association between the two. The sources of heterogeneity in the association between whorl patterns and dental caries were the investigations by Agarwal *et al.* [26], 2018, Devi *et al.* [32], 2020, and Mokhtari *et al.* [34], 2021; the omission of these papers would affect the conclusion that there was no association between the two factors. Although heterogeneity in the relationship between dental caries and loop patterns in females may have originated from Kattakayam *et al.* [35], 2022, the conclusion remained unchanged when excluding this particular study. Heterogeneity in our analysis of whorl and

loop patterns in males originated from Sengupta *et al*. [30], 2013; excluding this particular paper exerted influence on our final results. Excluding the study by Asif *et al*. [31], 2017 did not affect the conclusion attained by our analysis of arch patterns in males.

Our findings have made a significant contribution to the existing knowledge base related to the potential relationship between dental caries and dermatoglyphics. Our conclusions are consistent with earlier reviews [1]. In the present study, we integrated the relevant literature to accurately assess the relationship between the two factors and provide implications for future research. Dermatoglyphics is a non-invasive and economical tool and can be used to screen caries-prone children so that measures can be taken to intervent and treat this prevalent oral condition. Our analyses of gender revealed a correlation between fingerprints and caries in the female population, providing new concepts for future research. There are some several limitations to this research that need to be considered. Firstly, the meta-analysis included only eight studies. Most of the included studies were cross-sectional, and further prospective studies would help to improve causal inferences. In addition, significant heterogeneity was detected in some outcomes, and while sensitivity studies were performed to assess the stability of our results, it remains unknown as to what factor(s) caused some of the observed heterogeneity. Due to the possibility of confounding variables, the findings of this meta-analysis should be considered with caution. Since the majority of participants were from India and other Asian regions, further research from Western countries is now needed to obtain more clinical data that better represents the global population. Another limitation is that this report only investigated fingerprint patterns and did not cover other dermatoglyphic features; consequently, we were unable to establish a relationship between other dermatoglyphic indicators and dental caries. Finally, there were inconsistencies in the selection of DMFT that require improvement.

5. Conclusions

Based on the evidence from this meta-analysis, there was a greater correlation between caries and dermatoglyphics in women than men. However, overall, our analysis showed that there was no conclusive evidence connecting whorl, loop or arch patterns to dental caries. It is necessary to conduct more extensive prospective research to better understand the connection between dermatoglyphics and dental caries.

AVAILABILITY OF DATA AND MATERIALS

All relevant data are within the manuscript.

AUTHOR CONTRIBUTIONS

HQW and DLS—designed the research study. HQW, JJY and WBOY—performed the research. CKL and SOY—analyzed the data. HQW and XXX—wrote the manuscript. All authors contributed to editorial changes in the manuscript. All authors read and approved the final manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Not applicable.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

SUPPLEMENTARY MATERIAL

Supplementary material associated with this article can be found, in the online version, at https://oss.jocpd.com/files/article/1852190678871621632/attachment/Supplementary%20material.docx.

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