Assessment of lip print (cheiloscopy) patterns and its use for personal identification and crime investigation: A systematic review and Meta-Analysis

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Abstract

Objective:Human identification plays a vital role in crime investigation. Lip impressions are one of the evidences that may be left at crime scenes, which aid in the precise documentation process. The objectives of the current systematic review and meta-analysis (CMA) are to provide a deeper understanding of the use of cheiloscopy as a reliable method in sex identification and to establish the predominant lip print pattern found among different genders using the classification proposed by Suzuki and Tsuchihashi.

Study Design: A systematic review and meta-analysis

Result:The most likely lip print present among males in the selected studies was type III (30.2%), followed by type II (29.9%), and type I comprised one-fifth of the sample size (21.1%). While among females, almost one-third were reported with type I lip print pattern (36.5%), followed by type II (28.9%). Furthermore, the results showed that the rate of type IV lip print pattern was similar between males and females (18.3% and 13.4%, respectively; P<0.059).

Conclusion: Along with the other traditional methods of human identification, this study proved the distinctiveness of lip print (cheiloscopy) as an adjuvant tool for human identification and sex determination and no identically similar lip-print patterns appeared in two subjects. Further studies with larger sample sizes, different methodologies of assessing lip print are needed to confirm the current findings.

Review (J Int Dent Med Res 2023; 16(1): 331-339)

Keywords: Lip print, Cheiloscopy, Forensic Dentistry, Personal identification, gender identification.

Received date: 06 June 2022 **Accept date:** 11 January 2023

Introduction

Lip prints or Cheiloscopy (from the Greek words cheilos, “lips”, and skopein, “see”), have been described in the literature as an additional tool in criminal investigation because labial pattern grooves are unique and their scope of applicability is similar to those of fingerprints.[1] Visual identification is not always feasible, particularly after decomposition, oro-facial lip pathology, facial trauma/scars and skeletonisation.[2] In such cases, DNA profiling, fingerprints and odontology play an essential role. The correct identification of living or defunct individuals using the unparalleled nature and features of the human teeth and jaws forms a radix in the forensic field.[3]

Chieloscopy (lip prints) is the study of the characteristic pattern of normal lines or fissures in the form of lobulated elevations and depressions on the labial mucosa, sandwiched between the inner area of the labial mucosa and the outer part of the skin.[4] It is uniform throughout life. Lip print can be used as a valuable evidence in forensic dentistry because of their uniqueness and stability.[1, 2] A lip print found at a crime scene can lead to many inferences and provides details, such as the nature of the incident, the number of people entangled, gender, habits, occupational traits and presence of any pathology on the lips.[1]

Vats, *et.al.* studied the prevalence of particular lip print patterns among Brahmins, Jats, and scheduled castes of Delhi and Haryana, India and found that generally type III lip pattern

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according to Suzuki and Tsuchihashi classification was predominant.[2] However, Dongarwar, *et al*. (2013) in their study stated that Type IV and Type V patterns were dominant in males and Type I and Type I' patterns were dominant in females.[5] Likewise, for the purpose of sex determination, Sharma, *et al*. (2009) claimed that Type I, I' were most commonly seen in females, whereas Type IV was seen most commonly in males.[6] From the mid-1970s until 2000s, many studies have been conducted on lip print stability, gender determinations and various morphological pattern as each individual's lips have a specific pattern of fissures.[5-11] Furthermore, numerous previous reports[1-11] indicated that different racial and ethnic groups may show differences in the distribution of lip pattern. However, those studies lacked any exclusive conclusion on the relation of lip prints with age and gender. Hence, the objectives of the current systematic review and meta-analysis were to provide a deeper understanding of the use of cheiloscopy as a reliable method in sex identification, and to establish the predominant lip print pattern found among different gender using the classification proposed by Suzuki and Tsuchihashi.

Materials and methods

The current Systematic review and meta-analysis was conducted during September 2019 to March 2020 in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.

Eligibility criteria: Cross-sectional observational studies published, in which the age of the individual was mentioned to be above 18 years with an almost equal male to female ratio and sample size of 100 participants or more were selected for this systemic review and Meta-Analysis. Moreover, the selected studies characterised by, inclusion of up to 4 lip quadrants using a visible lip prints technique, as well as the use of dark lipstick and cellophane tape with or without magnifying lens and use of a Photoshop software as an adjunctive tool. The exclusion criteria include studies with the sample size less than 100 or patients below 18 years of age, it also covered articles that investigated the use of cheiloscopy in Disaster Victim Identification, medically compromised patients, participants with congenital or acquired oro-facial/lip pathology, including inflammation; traumatic/surgical scars; ulcers or any other soft tissue lesion; history of cleft lip surgery; allergy/hypersensitivity to lipsticks; or generalised skin allergy, such as angular cheilitis, lip pits, cheilitis glandularis and cheilitis granulomatosa.

Longitudinal studies with different objectives and methodology as well as studies based on the classification other than the one proposed by Suzuki and Tsuchihashi were also excluded.

Studies providing lip print type outcomes using latent lip prints technique, bright lipstick and use of software as the main technique to determine the type of lip prints were also excluded.

Furthermore, case reports, case series, presentations submitted to conferences, literature reviews, abstracts only, interviews, editorials, expert opinions and studies published in languages other than English were also excluded. The analysis of lip patterns was carried out according to the classification proposed by Suzuki and Tsuchihashi published in 1974,[12] in which lip prints were classified into six patterns, according to the shape and course of grooves as described in Figure 1: Type I: complete vertical pattern, Type I′: incomplete vertical pattern, Type II: branching or 'Y' pattern, Type III: crisscross pattern, Type IV: reticular pattern and Type V: all other patterns.

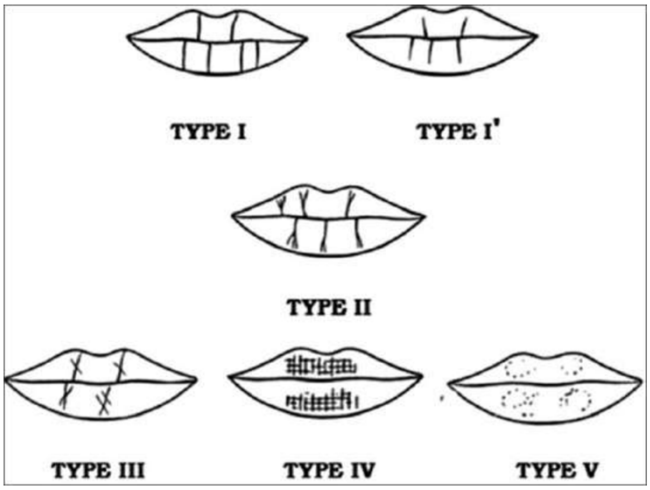

Figure 1. Suzuki and Tsuchihashi Classification of lip print

The triple blinding technique was used in most of the studies during lip print analyses. The

gender of the individual was determined as per the description given by Vahanwala *et al.*[13] in which Types I, I′ and II were commonly found in females, whereas Type III and IV patterns were predominant in males.

Source of information and search strategy: An exhaustive bibliographic electronic search for articles published between 1998 until September 2019 was conducted in six databases: PubMed, Scopus, and Research gate, Science Direct, EBSCO and Google Scholar. The search strategies were implemented based on the study objectives, and the keywords based on each section of the PICO question, with the following terms were included in the search strategy; Lip Print OR Cheiloscopy OR Forensic Dentistry OR Personal Identification.

Studies were initially selected based on the title and abstract. After that, the selected articles were read in full-text to check for their eligibility by two authors (MH and KH). In the case of disagreement between the authors, a consensus was attained. Data extracted include: author name and year of publication, studied population, study design, sample size, age range of the sample, gender, lip print method used, and materials used, percentage of lip patterns and sex estimation outcomes if present.

To assess the risk of bias in all selected full-text articles included in this study (Table 1), we performed the recommended NIH checklist.[14] The equality of the included studies was assessed independently by two authors (MH and KH). The studies were classified in three categories; good, fair and poor based on fourteen related questions which include: if the objectives of the study were clearly stated or not, was the study population clearly specified, weather the inclusion and exclusion criteria applied or not, the presence of validated outcomes and the study selection or analytical bias. Comparison between studies was based on a score calculated as 1 per question answered with *yes* and 0 per question answered with *no* or *not reported.* The higher the score, the better the scientific quality of the study. Quality assessment score ranged between 3 and 12 out of 14. Out of 34 included studies, 7 of them had a score below 5 (20.6%) and eventually get excluded from the systematic review, on the other hand, 13 (38.2%) studies were categorised as fair with score ranged from 6 to 8, while 14 (41.2%) studies scored between 9 and 12 out of 14 and categorised as good, each of them had a different missing points, (related to validation, discussion of analytical bias or selection bias). The specific information about the included studies were detailed in Table 1.

In general, a 'good' study has the least risk of bias, and the results are considered valid. While a 'fair' study is susceptible to some risk of bias deemed not sufficient to invalidate its results. The fair quality category is likely to be broad, so all studies with this rating will vary in their strengths and weaknesses. In contrast, 'poor' rating indicates significant risk of bias. Studies rated poor were excluded from the current systematic review and meta-analysis.
The value of weighted kappa statistic between author agreements was 91.17%. After confirming the quality of each study, two authors independently extracted the data from the selected full-text articles using a standardised electronic format (Office Word 2016 software, Microsoft Corporation)

Statistical analysis

The overall rates of lip print patterns in different studies per gender were collected and analysed using Comprehensive Meta-Analysis (CMA Version 3 Borenstein, M., Hedges, L., Higgins, J., and Rothstein, H. Biostat, Englewood, NJ 2013). The rates of lip print patterns for males and females were estimated with their associated 95% CI. The student t-test was used to compare the differences in the proportions of lip print patterns between males and females. In addition, the heterogeneity assumption among the included studies was evaluated by the Chi-square and I^2 tests, which was regarded to be statistically significant if $p < 0.01$ and I^2 values of 25%, 50% and 75% were normally assigned as low, moderate, and high estimates. Egger's test was performed to assess the potential publication bias.

Results

Study characteristics

As shown in figure 2, out of the 1193 studies, 87 studies were duplicated, 10 were excluded for screening reasons, and 628 studies were excluded as non-relevant. Out of 468 full articles assessed 34 studies were selected for full-text review with quantitative synthesis, and after quality assessment using NIH, seven articles were excluded. The extracted data from the selected studies were compiled into one table

which include a total of 5749 participants (2717 males and 3032 females).

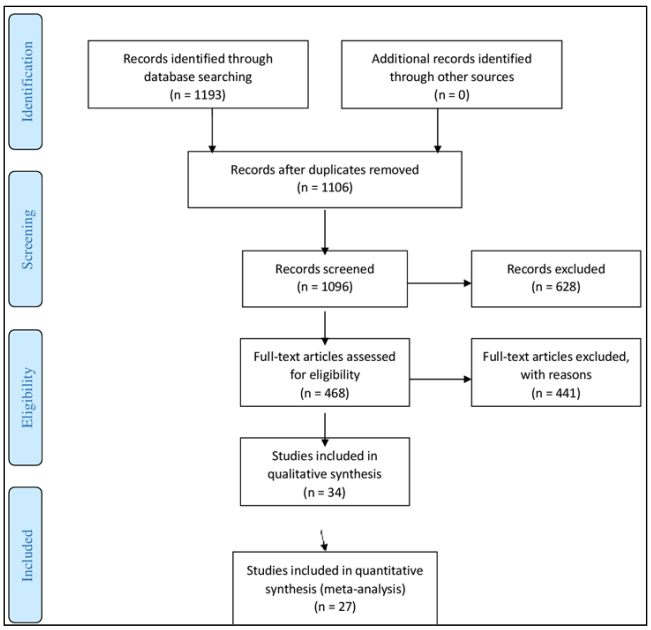

Figure 2. PRISMA flow diagram.

Assessment of heterogeneity and publication bias:

A forest plot of the estimation rate of type III (Figure 3) and type V lip prints (Figure 4) in males showed high heterogeneity as demonstrated by chi-square (Q- values) of 315.047 and 184.679, respectively with corresponding I^2 of 92.089 and 90.003, respectively and p-value < 0.01, as revealed by the random effect model. For the forest plot of the estimation rate of type I of lip print in females (Figure 5) showed a high heterogeneity, as demonstrated by the chi-square (Q-value) of 470.585 corresponding to I^2 of 95.018 and p <0.01 using the random effect model.

Meta-analysis pooling of the comparison between males and females p showed a moderate heterogeneity, as demonstrated by the chi-square (Q-value) of 85.501 and I^2 of 69.825, p<0.01 using the random effect model (Table 4).

Patterns of the distribution of lip prints (cheiloscopy)

In all of the 27 selected studies there were no two lip patterns are similar, thus establishing the uniqueness of lip prints, but there was a difference in gender-wise predilection of its pattern. The overall result of the Meta-Analysis of the estimation rate of lip print types per gender was displayed in table 2 for males and table 3 for females. The predominant lip print among males in the selected studies was type III (30.2%), followed by type II (29.9%). One-fifth of the sample size was type I (21.1%), followed by type IV (18.3%) and type I' (15%). Only 10.8% were reported with type V lip pattern. While almost one-third females were reported with type I lip print pattern (36.5%), followed by type II (28.9%), type I' (21.9%), type III (19.2%), type IV (13.4%) and type V (12.6%).

Table 4 describe the comparison of the types of lip print between male and females and the results showed that type IV lip pattern was similar between males and females (18.3% and 13.4%, respectively; P<0.059).

Type of Lip print	Male (2717) proportion (95% CI)	Heterogeneity Q (p-value)	Test of Bias (Intercept, -value) Egger's test (Funnel plot)	Sensitivity Begg test
Type I	21.1(19.4,22.9)	245.102 (<0.001)	-2.77358 (0.0370)	-139 (0.002)
Type I'	15 (1.3, 16.9)	255.674 (<0.001)	-4.99536 (0.00002)	-153 (0.0007)
Type II	29.9 (28,32)	363.175 (<0.001)	-6.39459 (<0.001)	-147(0.00117)
Type III	30.2(28.3, 32.2)	315.047 (<0.001)	-3.17436 (0.02469)	-133 (0.0097)
Type IV	18.3 (16.7, 20.1)	235.759 (<0.001)	-2.92415 (0.00835)	-101 (0.0185)
Type V	10.8 (9.4, 12.4)	184.679 (<0.001)	-3.47158 (0.000033)	-143 (0.0015)

Table 2. Patterns of the distribution of Lips print in males from the included studies.

Type of Lip print	Females (3032) proportion (95% CI)	Heterogeneity Q (p-value)	Test of Bias (Intercept, -value) Egger's test (Funnel plot)	Sensitivity Begg test
Type I	36.5 (34.5,38.5)	470.585 (<0.001)	-2.83227 (0.12827)	-132 (0.0031)
Type I'	21.9 (20.2, 23.8)	263.834 (< 0.001)	-4.6984 (0.00404)	-125 (0.0048)
Type II	28.9 (27.2, 30.7)	314.177 (<0.001)	-5.25081 (0.00001)	-66 (0.0877)
Type III	19.2 (17.7, 20.9)	198.37 (<0.001)	-3.43605 (0.00001)	-187 (0.00005)
Type IV	13.4 (12.1, 14.9)	172.808 (<0.001)	-2.45155 (0.00698)	-112 (0.01033)
Type V	12.6 (10.9, 14.5)	258.300 (<0.001)	-3.71409 (0.00003)	-93 (0.02756)

Table 3. Patterns of the distribution of Lips print in females from the included studies.

Type of Lip print	Difference Δ (95% CI)	p-value	Heterogeneity Q (p-value)	Test of Bias (Intercept, -value) Egger's test (FP)	Sensitivity Begg test
Type I	-0.098 (-0.116, -0.08)	<0.001	430.836 (<0.001)	-2.90910 (0.03328)	-17 (0.369)
Type I'	-0.014 (-0.022, -.0006)	0.001	175.403 (<0.001)	-2.10723 (0.00012)	-61 (0.105)
Type II	-0.020 (-0.039, -0.002)	0.033	85.501 (<0.001)	0.9942 (0.13723)	51 (0.148)
Type III	0.101 (0.083,0.118)	<0.001	400.701 (<0.001)	2.96007 (0.08255)	69 (0.078)
Type IV	0.014 (-0.001, 0.029)	0.059	145.931 (<0.001)	1.84406 (0.06066)	41 (0.202)
Type V	0.013 (0.004, 0.021)	0.003	192.44 (<0.001)	-0.01168 (0.49484)	47 (0.168)

Table **4.** Comparison of proportion of types of Lips print between males and females, using Comprehensive Meta-Analysis.

Discussion

In line with the previous observation, this study confirms the uniqueness of the lip prints to the individual and no two individuals have an exactly matching lip score. Thus, lip prints can therefore, be used as an evidence or a positive means of person identification just like fingerprints. This phenomenon could be explained by the idea that the borders of the lip contain sweat glands in between collection of sebaceous glands peripherally; thus, moisture and oil precipitates allow the appearance of latent or hidden lip prints similar to fingerprints.[1]

Different classification systems of lip print pattern have been proposed. Afchar Bayat classification is one of the proposed methods in which the lip groove patterns are divided into seven types.[36] Another classification of lip groove pattern is Renaud's classification where the lip patterns divided into ten types.[36] In the current systematic review and meta-analysis, we used an internationally accepted Suzuki and Tsuchihashi Classification system, which group lip groove patterns based on its morphology.[12]

The findings of the current study also confirms that no two-lip patterns matched each other, despite the noticeable variation in lip print patterns, a similar observations was reported by other investigators;[4] therefore, we can establish the uniqueness of lip patterns among different individuals.[6] Our analysis is in parallel with the findings reported by Tsuchihashi *et al.*[12] Furthermore, the most frequent lip print pattern in the entire population was type II, which coincides with the study done by Pradhuman Verma *et al.*[16]. However, a study conducted on Indo-Dravidian population by Sivapathasundharam et al. found that the type III pattern was predominant.[37] In contrast, Verghese *et al.,* concluded that type IV was predominant lip pattern.[7]

The current analysis reveals a huge variation in the configuration of the lip print forms in relation to gender. The most frequent lip print patterns observed among males was type III lip, followed by types II and I respectively. In females, type I was the commonly observed lip print pattern, followed by types II and I', respectively. Compared to another analysis done by Vahanwalla and Parekh, conflicting observations were noted in which type III was frequently recorded among males and type II among females.[12] Similarly, a number of previous studies reported different results, for example, Gondivkar *et al.*[38] Gordon[39], Verghese *et al.*[7] and Sandhu *et al.*[10] observed that types III, IV and I were the commonly observed lip print forms among both genders.

Moreover, the current analysis reported that the least frequent lip print pattern found in the study population was type V, which agrees with most of the former studies that showed noticeable variety in the pattern of lip prints among individuals of different age groups and generations.[11, 16, 17]

In spit the fact that most of the selected studies had clearly defined research questions, and outcomes, some lack appropriate inclusion/exclusion criteria, validation, reliability tests, sample size calculation and discussion of bias accounted for low quality assessment score in most of these studies (Table 1).

The variation and challenges faced by researchers which affected the accuracy of the reported results of the identity of the individual may be attributed to the variation in lip maturity among males and females, the ability of lips to maintain their tonicity in late 30s,[39] occurrence of wrinkles in the adjacent face and thinning of lips altering the lip morphology.[40]

Although this systematic review and meta-analysis study provides beneficial information about the lip pattern as an important tool in forensic investigation, it is obvious that the majority of the studies were from India and few were from Pakistan, Nepal and Malaysia, and hence the results cannot be generalised.

It is worth mentioning that a great amount of research has been conducted with the best intentions of building a solid foundation for this discipline in the forensic science, which is a pear to be promising and has great potential. However, in a recent report, Fonseca and co-workers[41] argued that the emergence of new legal requirements, validity and reliability of the techniques and the new methods which emphasize DNA analysis as a new standard, has led to a redefinition of "Forensic Science". A similar conclusion also raised by numerous authors who have highlighted concern about these methods because of inconsistent medicolegal investigations[42], and the questionable concept of "uniqueness" of the lip patterns.[43-45] Others investigators considered the technique a source of a real problem if it is to be considered evidence for personal identification.[45]

Limitations

The limitations of this study include differences in classification systems used and method of analysis of lip prints due to mobility of lip tissue as well as the amount of lipstick applied and the magnitude and direction of the pressure. Likewise, some investigators described smudging of lip prints among males due to presence of facial hairs is another limitation. Furthermore, post-mortem analysis of lip prints at crime scene has not been taken into consideration in the current systematic review.
Thus, an assumption can be drawn from the current systematic review, that lip patterns evaluation is used as one of the vital criminal tools for human identification on the basis of their gender distribution.

Although cheiloscopy has been used in court in isolated cases, it's noticeable that more research must be done to substantiate the distinctiveness of lip print patterns, and to establish an appropriate method of collection and interpretation of evidence so as to be acceptable in court as scientifically evidence based.

Conclusion

Along with the other traditional methods of human identification, this study proved the distinctiveness of lip print (cheiloscopy) as an adjuvant tool for human identification and sex determination and no identically similar lip-print patterns appeared in two subjects. Further studies with a bigger sample size, different methodology of assessing lip print are needed to substantiate the current findings.

Declaration of Interest

The authors report no conflict of interest.

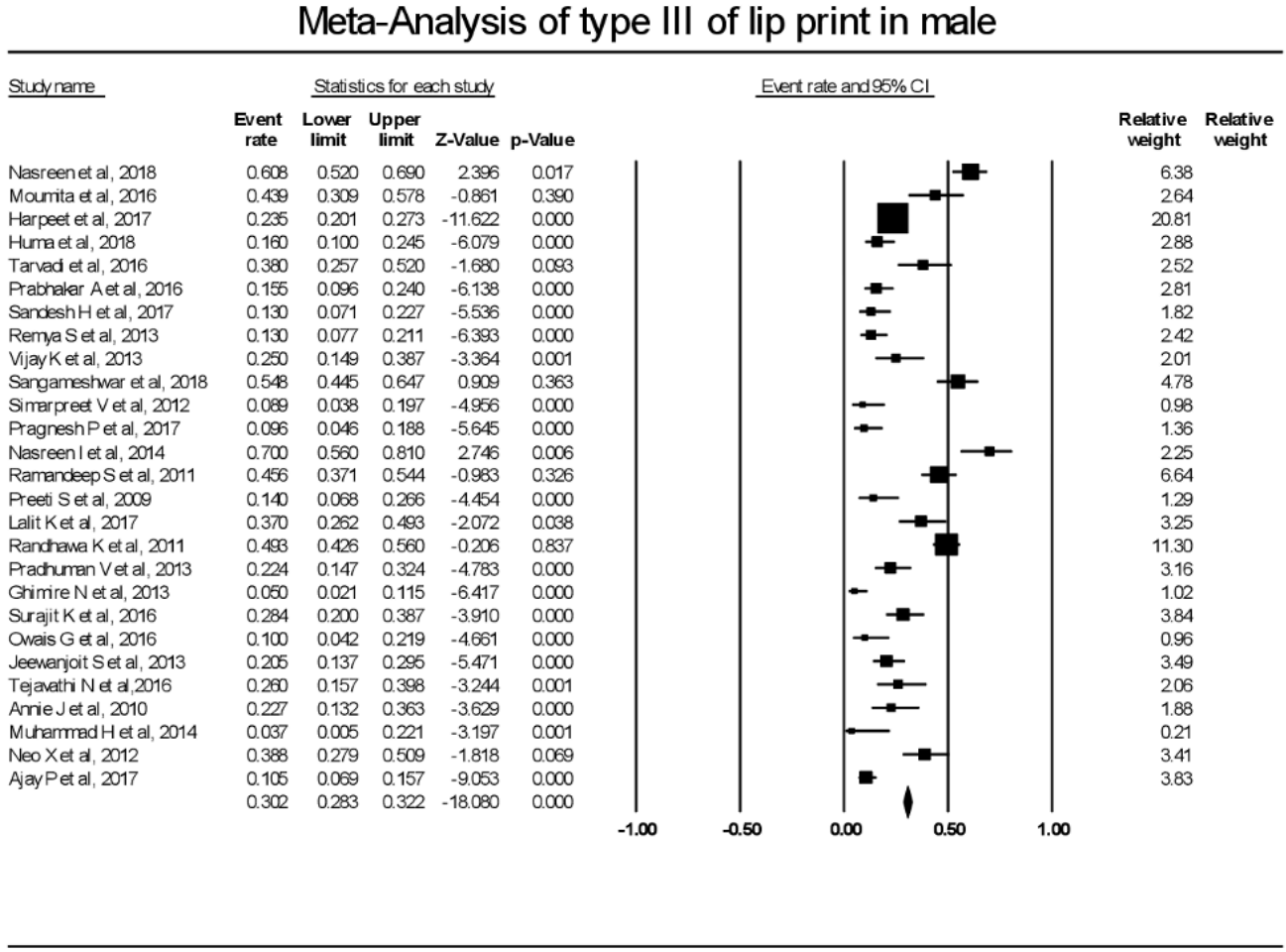

Figure 3. Forest plot of type III lip print pattern in males.

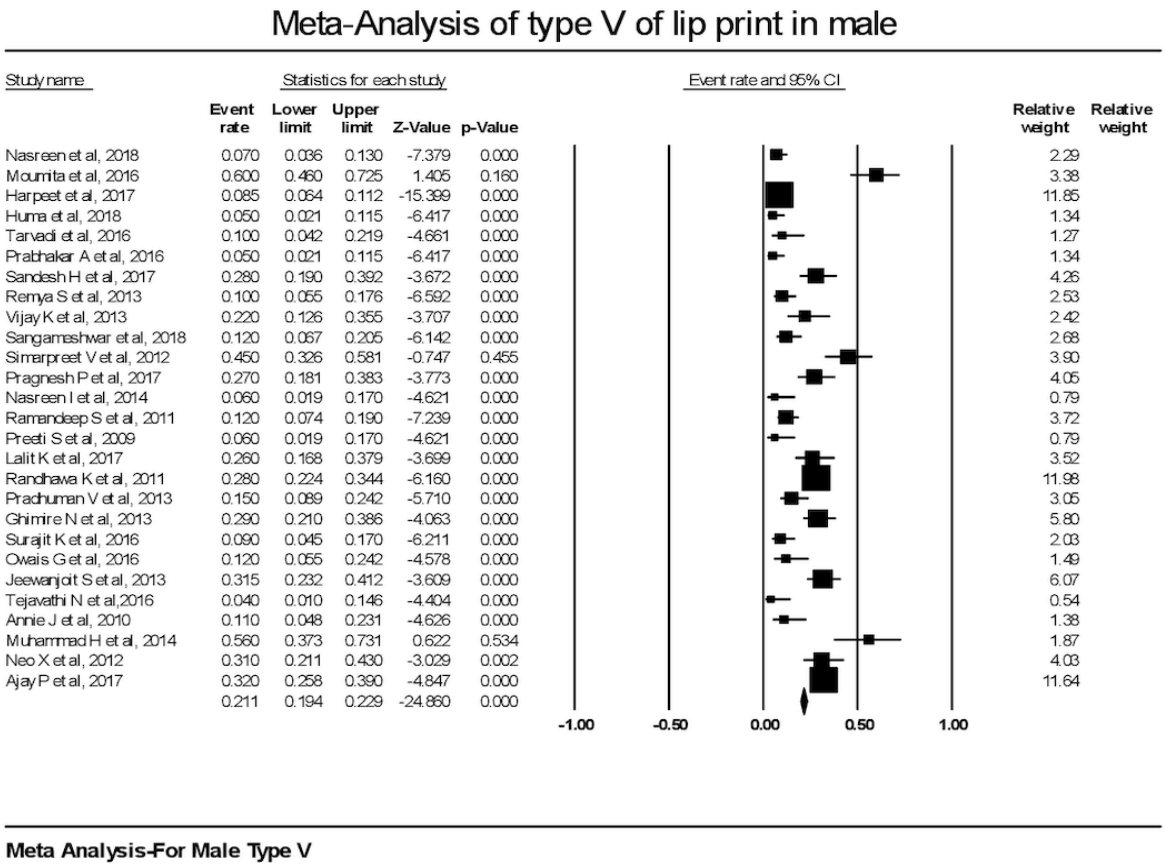

Figure 4. Forest plot of type V lip print pattern in males.

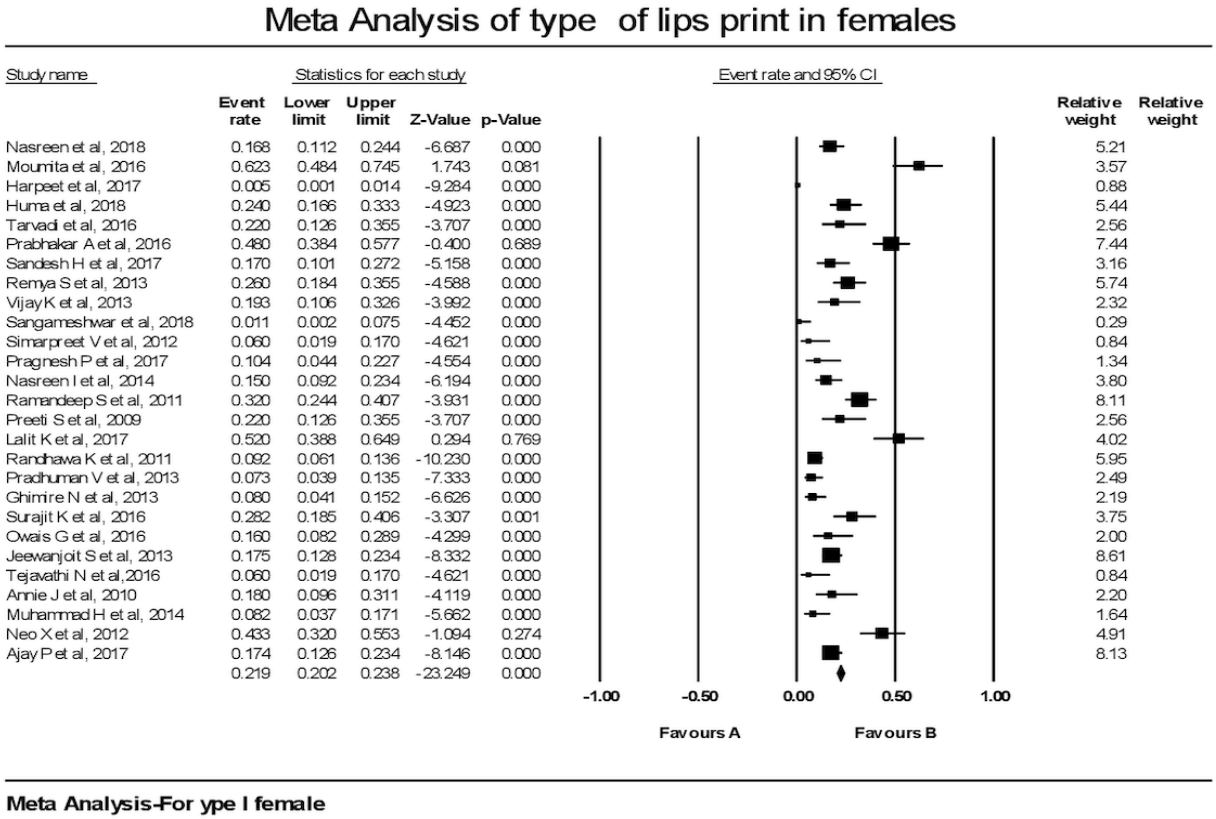

Figure 5. Forest plot of type I lip print pattern in females.

Author	Year of Publication	M/F	Age Range	Quadrants	Materials used	Sample Size	Quality Assessment Score
Sharma[6], et al.	2009	50:50	20-30	Middle part of the lower lip	Cellophane tape	100	10
Annie[7], et al.	2010	50:50	18-40	2 Q lower lip only	Cellophane tape	100	7
Ramandeep[8], et al	2011	125:125	20-40	The middle portion of the lower lip	Transparent cellophane tape	250	9
Randhawa[9], et al.	2011	211:239	21+	Middle part of the lower lip	Transparent cellophane tape	450	11
Simarpreet[10], et al.	2012	56-50	18-25	Middle part of the lower lip	Cellophane tape	106	10
Xiao [11], et al.	2012	67-67	20-26	4 Q	Cellophane tape	134	9
Kautilya[15], et al.	2013	50:50	18-25	6 Q	Transparent cellophane tape	100	11
Verma[16], et al.	2013	85:123	18-25	6 Q	Cellophane tape	208	8
Ghimire[17], et al.	2013	100:100	18-25	4 Q	Sheet of bond paper	200	9
Sekhon[18], et al.	2013	100:200	18-25	8 Q	Cellophane tape	300	8
Ishaq[19], et al.	2014	50:100	18-25	Not specified	Bond paper	150	6
Hammad[20], et al.	2014	27:73	19-25	Middle portion of the lower lip	White paper	100	10
Sinha[21], et al.	2016	50:51	18-35	4 Q	Cellophane tape	101	9
Tarvadi[22], et al.	2016	50:50	18-25	Middle portion of the lip	Transparent sheet	100	7
Jeergal[23], et al.	2016	100:100	18-60	8 Q	Cellophane tape	200	11
Remya[24], et al.	2016	100:100	18-23	Middle part of the lower lip	Cellophane tape	200	10
Kundu[25], et al.	2016	88:62	18-24	6 Q	Cellophane tape	150	7
Gowhar[26], et al.	2016	50:50	18-30	Not specified	Transparent cellophane tape	100	8
Nagaraj[27], et al.	2016	50:50	22-35	Middle portion of the lower lip	Cellophane tape	100	7
Sandhu[28], et al.	2017	540:660	18-30	6 Q	Cellophane tape	1200	12
Chaudhari[29], et al.	2017	75:75	25-50	4 Q	Cellophane tape	150	8
Parmar[30], et al.	2017	73-48	19-25	Not specified	Cellophane tape	121	6
Kumar[31], et al.	2017	65:54	20-28	Middle part of the lower lip	Cellophane tape	119	9
Pala[32], et al.	2017	190:190	18-25	Not specified	Scotch tape	380	6
Ishaq[33], et al.	2018	125:125	18-25	Not specified	Cellophane tape	250	7
Saleem[34], et al.	2018	100:100	18-30	Not specified	Cellophane tape	200	7
Manikya[35], et al.	2018	90:90	18-23	6 Q	Cellophane tape	180	10

Table 1. Quality assessment of the study.

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